AN ABSTRACT OF THE DISSERTATION OF

Jennifer Shalini Collins for the degree of Doctor of Philosophy in Science Education presented on December 10, 2015.

Title: Improving Science, Technology, Engineering, and Mathematics (STEM) Education At Public Research Universities: Considering Students’ Perspectives on Teaching-related Factors and Faculty Experiences, Motivations, and Competencies Concerning Teaching Improvement

Abstract approved: ______________________________________________________

Jana L Bouma-Gearhart

The underlying aim of my dissertation was to contribute knowledge that may better support and foster STEM education improvement initiatives at public research universities. The two research studies included in my dissertation advance knowledge per perspectives of key stakeholders targeted by initiatives attempting to foster change, students and faculty. In the first study, I used qualitative research methods to explore students’ perspectives concerning teaching-related factors in STEM courses, with enhanced attention to students’ felt affordances for their learning and engagement in STEM. In the second study, I used quantitative survey methods to investigate STEM faculty members’ engagement in teaching-related professional development (TPD), barriers to participation in TPD, and their motivation and related competencies associated with TPD.

My student-focused and faculty-focused studies are grounded in the notion that an individual’s actions (including the learning and engagement that education initiatives desire to improve) cannot be studied in isolation from context. My two studies are grounded in theories of affordances and sensemaking, allowing explanation of individuals’ actions based on their perceptions of the environment. To explore STEM faculty members’ experiences and motivation to participate in TPD, I also rely on self-determination theory, that posits different factors influencing autonomous or controlled motives to engage in a task (in this case, teaching-related professional development).
The findings that emerged from my student-focused study indicated that an overwhelming majority of the students in the study deemed “pure lecturing,” as a constraint to their learning and engagement. A plethora of perceived affordances concerning pedagogical practices and other factors were noted by students, beyond just favorable teaching methods (e.g., group work). In addition to specific teaching methods, other affordances included a variety of more general teaching methods (e.g., interactive lectures), instructional strategies (e.g., use of illustrations), students’ cognitive engagement opportunities (e.g., connections to real world), additional physical/technological resources (e.g., notes), and instructor personality traits (e.g., enthusiasm). In fact, the perceived affordances of students, taken together, present teaching practice as a complex and multifaceted practice.

The results of my faculty-focused study revealed that most STEM faculty in the study participated in TPD and many via multiple TPD experiences/activities, even in the face of commonly cited barriers such as lack of time and unfavorable institutional/departmental culture. Additionally, their participation in TPD was mostly regulated by autonomous reasons compared to controlled reasons. However, controlled reasons were still significant, especially for earlier-career faculty, and reduced with subsequent TPD participation. Lastly, my results indicate that STEM faculty who participated in TPD felt more competent to teach compared to those who did not participate in TPD and, more specifically, full professors felt more competent to teach compared to associate and assistant professors.

My dissertation calls to attention the importance of engaging students and faculty in conversations and considerations related to educational practice and related improvement efforts. When external environments are perceived with affordances to improve pedagogical practices, faculty will more likely participate in activities that promote research-confirmed effective teaching practices. When faculty implement effective practices that place students as central, the classroom environment will be packed with affordances that support student success in STEM within the walls of the university and beyond.
Improving Science, Technology, Engineering, and Mathematics (STEM) Education At Public Research Universities: Considering Students’ Perspectives on Teaching-related Factors and Faculty Experiences, Motivations, and Competencies Concerning Teaching Improvement

by

Jennifer Shalini Collins

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APPROVED:

Major Professor, representing Science Education

Dean of the College of Education

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

______________________________
Jennifer Shalini Collins, Author
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CONTRIBUTION OF AUTHORS

**Student-focused Study.** Dr. Jana Bouwma-Gearhart (Oregon State University, Co-PI of research project) and I worked with two other colleagues (not co-authors) in close collaboration in the co-development of the research design, including recruitment of participants, co-development of interview protocols, and co-collection and organization of data. I independently conducted all data analysis pertinent to the study. Dr. Jana Bouwma-Gearhart contributed to the conceptualization, writing, and editing of the manuscript.

**Faculty-focused Study.** Dr. Jana Bouwma-Gearhart (Oregon State University) and Dr. Stephen Schmid (University of Wisconsin College System) and I worked together in close collaboration in the co-development of the research design, co-collection and organization of data. I independently conducted all data analysis pertinent to the study. Dr. Jana Bouwma-Gearhart contributed to the conceptualization, writing, and editing of the manuscript.
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CHAPTER I

Introduction

Motivation for the Dissertation

Lack of student interest and engagement, leading to low rates of baccalaureate degree completion in science, technology, engineering, and mathematics (STEM), are among the most pressing and complex struggles for the US higher education system (Higher Education Research Institute, 2010; National Research Council, 2012). Collectively framed as the STEM education crisis in the US, this issue has been increasingly amplified in public discourse, research journals, national policy reports, and even the mainstream media. A recent report by the Higher Education Research Institute (HERI) (Degree of Success: Bachelor’s Degree Completion Rates among Initial STEM Majors, 2010) revealed that not only are first-year STEM majors more likely to switch fields of study before they graduate, but they are also more likely to drop out of college than their non-STEM counterparts. The high attrition rates of undergraduate students from STEM fields are particularly alarming given the current US economic climate (National Research Council, 2012). The President’s Council of Advisors on Science and Technology (2012) reported that the United States needs an additional one million STEM graduates in the coming decade to meet STEM workforce demands and to remain economically successful and globally competitive. Given the deficiencies in education pathways leading to STEM degrees and into the workforce, improvement in undergraduate STEM education has taken on a new urgency as a national policy priority in recent years (Association of American Universities, 2011).

While the increased attention on STEM education is driven mostly by perceptions concerning the nation’s workforce demands, an additional imperative concerns fostering a more scientifically-literate US populace, as evidenced via calls from diverse stakeholders, represented in the mainstream media to those affiliated with disciplinary scientific organizations like the National Academy of Sciences (Mathieu, Pfund, & Gillian-Daniel, 2009; National Research Council, 2012; Weiman, Perkins, & Gilbert, 2010). Improvements to formal US postsecondary STEM education holds potential for helping to address these concerns. With an estimated 20.6 million students enrolled in US college and universities, many students, regardless of their
majors, take at least one introductory STEM course as an undergraduate as part of their general education course requirements (National Center for Education Statistics, 2015). Therefore, postsecondary STEM programs, and the faculty that teach in them, have a unique opportunity and responsibility to ensure that all students, regardless of their future career paths, gain the basic STEM competencies needed to learn about and address the daunting challenges of the 21st century (American Association for Advancement of Science (AAAS), 2011; National Research Council, 2012).

To address the calls for a diverse technical workforce and science-literate citizenry, government officials, education policy makers, researchers, university administrators, and faculty have united in recent years around a common goal of improvement to formal postsecondary education STEM experiences (PCAST, 2012; Weiman, 2009). Towards more effective, educational experiences for all, there has been enhanced focus on STEM classrooms and educators (Handelsman, Miller, & Pfund, 2009; National Research Council, 2012). Indeed, the improvement of STEM faculty members’ teaching practices in undergraduate classrooms is central to the concerted effort of transforming postsecondary STEM education and is central to a plethora of postsecondary STEM education improvement initiatives (Bouwma-Gearhart, 2012; Henderson, Beach, and Finkelstein, 2011; Fairweather, 2008) that intend, as ultimate results, the more widespread enactment to research-confirmed teaching practices resulting in better student learning and engagement.

The underlying aim of my dissertation was to add to the field of knowledge to better support and foster these STEM education improvement initiatives at public research universities via advancing knowledge per perspectives of key stakeholders targeted by these initiatives, the faculty and students.

**Considering the Students and Faculty Perspectives**

I contend that it is equally important to consider both the student and faculty perspective, not just to inform change initiatives in postsecondary STEM education, but to also build an overall well-functioning education system (AAAS, 2012). I adopt Lea, Stephenson, and Troy’s (2003) perspective, who argued eloquently for consideration of both faculty and student perspectives to better understand the complicated nexus of education, involving the instructor-learner relationship, towards building better education experiences for all:

The student’s view is a valid part of the negotiation between the instructor and learner.
Such negotiation about the learning experience is crucial to maximizing success in terms of learning outcomes for all students, and not just the highly committed and exceptionally skilled minority (p.333).

**Potential Value of Students’ Perspectives.** As stakeholders and recipients of higher education, students have the potential to be a valuable resource in all phases of STEM education improvement efforts, not just as providers of data regarding an initiative’s efficacy, but additionally in its proposal, visioning, planning, and implementation. As experts in their learning experiences, students, just like faculty members and administrators, have the ability to identify problems and deficiencies in education, and determine possible solutions and strategies to improve education offerings, in ways that respond to the growing diversity of students and future work paths (Cook-Sather, 2011; Lea et al., 2003). A commitment to hearing and responding to students’ perceptions of their education experiences is, in fact, in line with pedagogical strategies promoted by many STEM education improvement initiatives; as argued by Lea, Stephenson, and Troy (2003) noted, “If education is to be truly student-centered, students should be consulted about the process of learning and teaching” (p. 321). Considering students’ perspectives is essential because of the various ways they can inform existing conversations about education transformation, re-inform existing conversations, and also identifying discussions and reform efforts yet to be implemented (Cook-Sather, 2011; Levin, 2000). I argue that nation-wide undergraduate STEM education improvement efforts will be more successful when students’ perspectives are recognized and considered in defining, planning, and implementing change in higher education.

**Potential Value of Faculty’s Perspective.** The role of faculty in STEM education improvement, and their perspectives on teaching and learning overall, is incredibly significant in determining the fate of postsecondary STEM education. A growing body of scholarship strongly advocates for the importance of listening to and responding to faculty needs and expectations as means for achieving improvement of US undergraduate STEM education (Bouwma-Gearhart, 2012; Fairweather, 2008; Dancy & Henderson, 2008; Hora, 2011). Dancy and Henderson (2008) tie the success of postsecondary STEM education reform efforts to the participation and support of faculty members eloquently, with “we do not expect any reform effort to be successful unless it involves faculty as meaningful participants” (p. 11). I join others in arguing that it is essential to highlight the instrumental role of individual faculty members in STEM education
improvement efforts because, ultimately, they are the ones that adopt or reject new policies and interventions based on their own expectations and experiences, local climate, and pressures that influence their classroom practice (Bouwma-Gearhart, 2011; Hora, 2011).

**Structure of Dissertation**

The two research manuscripts presented in my dissertation advance knowledge on the state of educational practices and structures in STEM disciplines at research universities (RUs) based on the perspectives of two key stakeholders, students and faculty, respectively. Specifically, in the first empirical study (Chapter 2), I explore students’ perspectives on undergraduate STEM education at RUs, generally speaking and particularly related to teaching practices in STEM courses. In the second empirical study (Chapter 3), I explore STEM faculty members’ participation patterns and motivations to engage in teaching-related professional development (TPD), as well as links between this participation and their overall professional competence with respect to teaching and doing research.

**The Research Context**

My focus is on the experience of students and faculty at public RUs. RUs largely set the norms for how to teach science and what it means to learn science (Wieman, Perkins, & Gilbert, 2010); thus research concerning improving STEM education at RUs requires heightened attention. In 2009, US public RUs enrolled 33% of first-time, full-time undergraduate students (National Science Board, 2010). Thus, although public RUs represent only 10% of all US 4-year colleges and universities, they enroll a large percentage of students including students from underrepresented minority groups (Katkin, 2003). Furthermore, according to a report by the Association for Public and Land-Grant Universities (APLU), among the one million minority students enrolled at RUs, 80% attend public RUs (McPherson, Gobstein, & Shulenburger, 2010). In addition, public RUs are known to train the majority of the future faculty members, specifically in STEM disciplines (Austin, 2002; Gaff & Lambert, 1996). Finally, public RUs are widely recognized as a national asset in the area of education making significant impacts on educational practice at all levels including K-12 (National Science Board, 2012).

**Research Context for Student-focused Study**

This qualitative study is part of a larger multi-year NSF-funded research project, *Tracking the Process of Data-Driven Decision-Making in Higher Education (TPDM)*, that
employed a mixed methods approach design to investigate data-driven decision making related to curriculum and instruction in STEM disciplines at public RUs (details can be found on the project website: www.tpdm.wcer.org). In 2013, my research team including draws, including myself (as a project assistant), my doctoral advisor (Dr. Jana Bouwma-Gearhart, the Oregon State University Project Investigator), and two other colleagues (Dr. Matthew Hora and project assistant Amanda Oleson, both from the University of Wisconsin-Madison), collected student data for the Phase 1 of the TPDM project at three large, public RUs in the United States and Canada, specifically from the following four STEM disciplines: biology, geosciences, mechanical engineering, and physics. These study institutions were selected based on their similarities in type, size of undergraduate student enrollment, research activity, external grants and funding, and accreditation requirements in the STEM disciplines (Carnegie Foundation for the Advancement of Teaching, 2014; Universities Canada, 2014).

**Research Context for Faculty-focused Study**

This quantitative study is part of a larger study, employing a two-phase exploratory and sequential mixed-methods design; data for the quantitative phase of the study (the subject of this paper) was collected via a mostly quantitative survey. In 2010, my research team, including myself, my advisor (Dr. Bouwma-Gearhart), and colleague from the University of Wisconsin College System (Dr. Stephen Schmid), collected faculty data from various STEM disciplines including agricultural sciences, life sciences, engineering, and mathematics, specifically at three large, public RUs located in the southeastern region of the United States. We selected these study locations because of their similarities in the size of their undergraduate populations, research activity, external grants and funding, and accreditation requirements in STEM disciplines; all were classified as RUs with very high research activity (RU/VH) (Carnegie Foundation for the Advancement of Teaching, 2014).

**Researcher’s Ontological and Epistemological Assumptions**

My ontological stance acknowledges that the multiple realities of faculty and students are shaped by their personal conceptions, influenced by the educational environment within which they are embedded. My epistemological stance is anchored in the pragmatic constructivist approach in exploring the generation of knowledge, understanding, and meaning around phenomena; my research methodology acknowledges these human interactions in shaping realities (Guba & Lincoln, 1994). I make the assumption that my research participants can make
sense of their realities, shaped by their perceptions of affordances situated within their
environment, as well as share their realities with me and that I can interpret these realities with
good fidelity. These perspectives resonate with my own beliefs about the world, the construction
of knowledge, the value of subjectivity in research, as well as my own commitments to
improving education, including commitment to involve key stakeholders (student and faculty) in
visioning and enacting education improvement activities.

**Purpose and Research Questions**

**Study 1: Considering Students’ Perspectives**

My study intended to give students an opportunity to share, in their own words, their
perspectives on the undergraduate STEM education environment at RUs, and to provide
interpretation of their perspectives to the larger STEM education community, especially the
subsection of this community committed to improving undergraduate STEM education. Drawing
on theories of affordances and sensemaking, I sought to answer two primary, and interrelated,
questions via qualitative methods:

1. What are students’ perspectives on the undergraduate STEM education
   environment at research universities, specifically those they perceive as
   affordances/constraints regarding their academic success?
2. What are students’ perspectives on teaching in STEM courses, specifically those
   they perceive as affordances/constraints regarding their learning and engagement?

The sampling frame for this study included undergraduate students enrolled in biology,
geosciences, physics, and mechanical engineering courses at the three selected RUs. Student for
this were recruited from courses taught by instructors who were also participants in the larger
TPD project. Request for participation in study was sent via an email message from their
respective instructors. Qualitative data for this study was collect via semi-structured Focus
groups and one-on-one interviews. The semi-structured interview protocol was co-developed by
all members of the TPDM project. The audio recordings of interviews were professionally
transcribed for analysis. Transcripts were stored electronically using NVIVO®, a qualitative data
analysis and management software.

**Study 2: Considering Faculty’s Perspectives**

The purpose of this current study was to examine RU STEM faculty members’ TPD
experiences, including motivation to engage in TPD and their perceived level of competence
potentially influencing and resulting from their TPD participation, with a large array of STEM faculty members, with diverse academic tenure-track titles (assistant, associate, or full professor). Drawing on theories of affordances, sensemaking, and self-determination theory, I sought to answer two primary, and interrelated, questions via quantitative methods:

1. What are the general trends in RU STEM tenure-track faculty participation in teaching-focused professional development (TPD)?
2. What motivates faculty to engage in TPD? What are the positive affordances?
3. What are the barriers to faculty participation in TPD? What are the negative affordances?
4. How does faculty motivation for initial participation in TPD compare to subsequent (or more recent) participation in TPD?
5. How does faculty competence in teaching compare to their competence in conducting research and how is this related to TPD participation?
6. Do the experiences implicated in questions 1-5 differ across official points in career, by assistant-, associate-, or full-professor designations?

Email invitations to complete the online survey were sent to all identifiable STEM faculty at the three selected RUs in the US. The online survey was co-created with my co-investigators, Dr. Jana Bouwma-Gearhart and Dr. Stephen Schmid, based on the qualitative phase findings and pertinent parameters from self-determination theory. Two well-established SDT questionnaires were modified and included to assess perceived competence with respect to respondents’ teaching and research practices, as well as the reasons for participating in TPD. The complete survey consisted of Likert scale and open-ended items within Survey Monkey, a web-based survey development software program. Based on the purpose and research questions that guided the study, the format of the survey was organized to assess: (a) faculty motivation to engage in TPD, including motivation for initial and more recent participation in TPD activities; (b) the strength of SDT as an explanatory theory, including its underlying constructs, in accounting for the experiences of a greater number of STEM faculty from RUs, (c) factors that served as affordances (both positive and negative) for faculty participation in TPD, and (d) perceived competence for research and teaching, specifically in relation to participation in TPD. Thus, items were developed that could explicitly test findings from the qualitative phase, as well as other factors potentially impacting motivation to engage in TPD. I conducted all the
appropriate statistical analysis including t-tests and ANOVA was conducted based on the research questions.

**Conceptual Frameworks**

My dissertation draws on multiple theoretical frameworks including previous research to address the research questions of each study, and to ensure that the findings and potential implication are rooted in well-established theoretical perspectives:

**Theories of Affordances and Sensemaking**

I root both my study concerning students’ and faculty experiences in STEM disciplines at RUs, generally speaking, and teaching practices in STEM courses, specifically, in Gibson’s school of thought known as *ecological psychology*, rooted in an organismic view or reality. Gibson posits that an individual’s actions (including learning and engagement) cannot be studied in isolation from the individual’s environment (Gibson, 1979). In fact, the “world,” as conceptualized by Gibson, consists only of those things perceived by individuals in its environment (Gibson, 1979). Central to Gibson’s (1979) view of the world is the concept of *affordance*, or the opportunities for individuals’ actions based on their perceptions of the environment. According to Gibson (1979), “the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill” (p. 127). Gibson’s concept of affordances is rooted in a sensory perception of the natural world (hence the term ecological psychology). Gibson’s affordances is best illustrated by Sadler and Given’s (2007) description of how a rock is perceived by a reptile and a human:

A reptile in a desert might perceive a large rock as a place to sunbathe or a place to hide; a human might perceive the same rock as a weapon or a building material. There is no “correct” use for the rock, only the affordances perceived by various perceivers (p. 117).

This relationship between organisms and the environment lies at the heart of the concept of affordance (Sadler & Given, 2007). However, a noted deficiency of affordance theory is a lack of attention to how an organism makes sense of an affordance. I thus also rely on the theory of sensemaking which stipulates that organisms (including humans) situate perceptions of affordances in preexisting mental constructs (*schemas*) that have been themselves constructed via their experiences with other environmental affordances (Letiche & Lissack, 2009).

**Motivation and Self-Determination Theory**
Many modern motivational theories are of the cognitivist as well as socio-cultural veins, and assume that human cognition in response to environmental stimuli, what I have conceptualized as *affordances*, including social and cultural affordances, best explains most human behavior; in fact, a wide array of rigorous research confirms this assumption. For purposes of this study, I use one of many well-tested theories of motivation, *self-determination theory* (SDT), as a theoretical framework, alongside affordance theory, to explore STEM RU faculty participation and motivation to engage in TPD. Self-determination theory (SDT) is based on the premise that humans naturally coordinate their actions to foster their growth towards satisfying three basic psychological needs: *competence, relatedness*, and *autonomy* (Deci & Ryan, 1985, 2002). Based on the extent to which the social environment supports or constrains the satisfaction of the three basic psychological needs, human beings can either be regulated by *autonomous* or *controlled* motives to engage in a task (Deci & Ryan, 1985). A *regulation* involves an individual’s felt sense of choice and acting with a sense of volition or willingness (Deci & Ryan, 2000).

Individuals are considered to be *externally regulated* when they engage in an activity to meet external demands, avoid punishment, or obtain a reward (Deci & Ryan 2000). For instance, some faculty might be focused on improving their teaching compared to others because they were promised rewards for being among the top teachers in their departments. Individuals are *intrinsically regulated* when they find the activity or goal inherent interesting and enjoyable, largely attributable to the nature of the activity. For example, a faculty member may be motivated to participate in teaching-focused professional development activities because they inherently interested in improving their practice to better support the learning of their students. *Well-internalized extrinsic motivation* is considered to be a more autonomous, or self-determined, form of motivation, via processes known as *identification and internalization*. These forms of extrinsic motivation involve personal endorsement of activities or goals, not to inherent enjoyment with respect to them, but because of their emergent value to an individual (Deci & Ryan, 2000). For example, individuals who perceive activities or goals that are competitive in nature may be extrinsically motivated but still autonomously regulated as they have identified and/or internalized the value of such activities leading to the attainment of a long-term plan, such as gaining promotion at a job. Because both intrinsic and identified/internalized forms of external
regulations involve choice and volition, they are often combined under the conceptual umbrella of *autonomous motivation* (e.g., Vansteenkiste et al., 2004).

Self-determination theorists sometimes discuss motivation at a level of discrete regulations (e.g., intrinsic motivation), whereas at other times, scholars take a broader perspective, examining the overall degree to which individuals feel self-endorsement and ownership versus pressure over their behavior. I utilize both approaches in this study.

**Findings**

The findings that emerged from the student-focused study (Chapter 2) provide a descriptive overview of students’ perceived constraints and affordances for their success in STEM disciplines, with *success* being defined as their *learning* and *engagement* in STEM. The most significant constraint noted by students was what they perceived to be the poor quality of instruction they encountered STEM classroom environments. More specifically, STEM faculty who do not value teaching and who were not interested in making the efforts to teach more effectively were perceived as constraints for students’ learning and engagement in STEM courses. Interestingly, students largely attributed these faculty characteristics to the unfavorable academic culture that glorifies research productivity at the expense of teaching effectiveness. In fact, students noted that the unfavorable culture influenced was a major barrier for why faculty lacked the motivation to improve their practices.

With respect to teaching practices, specifically, an overwhelming majority of the students in the study deemed “pure lecturing,” during which instructors talk continuously while students have to passively receive information, as a constraint to their learning and engagement. Yet there is evidence, both anecdotal (Weiman, Perkins, and Gilbert, 2009) and empirical (Hora & Ferrare, 2014; 2013) that this form of instruction continues to be the dominant way undergraduate students are taught in STEM courses (Handelsman, et al., 2009; Mazur, 2013; National Research Council, 2012). A plethora of perceived affordances concerning pedagogical practices and other factors were noted by students, beyond just favorable teaching methods (e.g., group work). In addition to specific teaching methods (e.g., small group work), other affordances included a variety of more general teaching methods (e.g. interactive lectures), instructional strategies (e.g. use of illustrations), students’ cognitive engagement opportunities (e.g., connections to real world), additional physical/technological resources (e.g., notes), and instructor personality traits
(e.g., enthusiasm). In fact, the perceived affordances of students, take together, present teaching as a complex and multifaceted practice.

Students’ perspective on teaching align with the thinking of several researchers who advocate for teaching to be studied as a complex and multidimensional phenomenon. Students in my study, additionally, articulated teaching in ways that confirms what is known about best practices in the fields. For instance, students’ perceived critical thinking and cognitive engagement as important aspects of learning, and they preferred faculty who encouraged these practices in the classroom.

Findings from the faculty-focused study (Chapter 3) revealed that most STEM faculty in the study participated in TPD and many via multiple TPD experiences/activities, even in the face of typically cited barriers of lack of time and unfavorable institutional/departmental culture. Additionally, their participation in TPD was mostly regulated by autonomous reasons compared to controlled reasons. However, controlled were still significant, especially for earlier-career faculty, and reduced with subsequent TPD participation. The most common barriers reported by STEM faculty was concerning lack of time and unfavorable institutional/departmental culture. Lastly, my results indicate that all faculty, regardless of academic title or participation in TPD, had a higher level of competence for teaching compared to their competence for research. However, investigation also revealed those who participated in TPD felt more competent to teach compared to those who did not participate in TPD and that full professors felt more competent to teach compared to associate and assistance professors.

**Potential Impact of Research**

I assert that my dissertation findings hold promise for informing practices, policies and other structures, as well as future research, concerning postsecondary STEM education and its improvement. The primary goal of my dissertation is for policy makers, education researchers, and faculty to consider multiple perspectives towards advancing understanding of educational practices and its improvement, especially at a time when many institutions of higher education are in the midst of activity to transform STEM education.

To better support undergraduate STEM improvement efforts, researchers and institutions must gather richer student accounts of teaching and their learning, accounts that go beyond simple ratings of preferences for “active learning” versus “traditional lecture” teaching methods. Higher education researchers, as well as postsecondary education administrators, policy makers,
and faculty can all benefit from richer and more nuanced data of student perspectives of teaching and learning, perspectives themselves that amount to rich and nuanced notions of teaching, to both advance understanding of current practices and foster related improvements. I encourage future research studies to employ more open ended approaches, in which students are given opportunities to share their perspectives on teaching and experiences in STEM courses, to gain a more holistic understanding of current educational practices in STEM education, specifically concerning teaching practices that are perceived as affordances (and not) for students’ learning and engagement in STEM courses and programs.

In addition, to build effective professional development programs that result in effective change in faculty classroom practices, attitudes, and beliefs—and ultimately change in the learning outcomes of students—institutional leaders need to consider faculty’s perspectives, including their motivation for participation in TPD, to develop more strategies to encourage participation in teaching improvement activities and efforts. It is necessary for those working towards instructional and organizational change to understand faculty realities that differ with time in position and per earlier TPD engagement, to ensure that engagement in professional development serve as an effective leverage for change in STEM education.
CHAPTER II

Constraints and Affordances Perceived in Undergraduate Education Environments: Considering Students’ Perspectives to Better Support STEM Education Improvement Efforts At Public Research Universities

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The Status of Undergraduate STEM Education in the United States

Over the last three decades, a common mantra has emerged in numerous national education policy reports, that undergraduate education in the science, technology, engineering, and mathematics (STEM) disciplines needs improvement.¹ The increased focus on STEM education is primarily driven by the fact that these highly technical postsecondary programs are a major source of the skilled scientific and technical workforce of the future, central to the nation’s ability to maintain a preeminent economic position in the world (Association of American Universities, 2011; National Research Council, 2012). Private and public sectors, including federal agencies, rely heavily on the U.S. postsecondary education system to equip individuals with fundamental STEM knowledge and skills needed to develop an adequate STEM-focused workforce, in both competencies and size. Several recent projections indicate that over the next decade or so the number of STEM jobs are expected to grow at a relatively fast pace (National Research Council, 2012); a 2011 report published by the US Department of Commerce indicated that from 2008 to 2018, STEM-related jobs are expected to grow 17.0% compared to just 9.8% percent for non-STEM jobs. US business and industry leaders frequently voice concerns that the current supply and availability of STEM professionals is not enough to fill these STEM-related jobs (US Department of Commerce report, 2011) and point to one part of the problem, not enough students graduating with STEM baccalaureate degrees. In fact, more than 60% of the students who originally indicate interest in science and mathematics end up switching majors during the first years of college (PCAST, 2012). Moreover, despite ongoing efforts to narrow racial achievement gaps, the rates of participation of underrepresented racial minorities² in

¹These include Undergraduate Science, Mathematics, and Engineering Education, National Science Board (1986); Science for All Americans, American Association for the Advancement of Science (1989); Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology, National Science Foundation (1996); Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology, National Research Council (1999); Evaluating and Improving Undergraduate Teaching in Science, Technology, Engineering and Mathematics, National Research Council, 2003; Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, National Research Council, 2007; Vision and Change in Undergraduate Biology Education: A Call to Action, American Association for the Advancement of Science, 2011; Discipline-based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering, National Research Council., 2012; Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics, President’s Council of Advisors on Science and Technology (PCAST), 2012.

²Underrepresented racial minorities refers to individuals such as African Americans, American Indians, and Latinos, whose rates of participation in STEM fields lag behind White and Asian Americans (Hurtado, Newman, Tran, & Chang, 2010).
STEM fields lag behind their White and Asian Americans counterparts (Hurtado, Newman, Tran, & Chang, 2010; National Science Foundation, 2013). The President’s Council of Advisor’s On Science and Technology noted, in their 2012 Engage to Excel report, that an additional one million college STEM graduates are needed over the next decade for the US to remain globally competitive in science and technology. Indeed, undergraduate STEM education transformation is a top national policy priority and has taken on a new urgency in recent years (Association of American Universities, 2011).

While the increased attention on STEM education is driven mostly by concerns for the nation’s workforce, an additional push has centered on the perceived lack of STEM literacy among the US populace (National Research Council, 2012; PCAST, 2012). According to the Committee on STEM Education of the National Science and Technology Council (2013), the economic progress and the social well-being of the nation depends not only on a well-trained technical workforce, but on a public that is scientifically-literate. The National Science Foundation defines scientific literacy as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (National Research Council, 1996, pg. 22). A growing number of key stakeholders have underscored the perceived lack of scientific literacy in the population and are calling on higher education to help address this concern (Gonzalez & Keunzi, 2012; Matheiu, 2010; The Coalition for Reform of Undergraduate STEM Education, 2014; Weiman, 2007). Remedying STEM illiteracy is an especially pressing concern as humanity faces profound challenges related to health, preserving the environment, population and resources, and energy (National Research Council, 2012). It is also important to ensure that the public is prepared to use STEM knowledge in personal and professional settings in which competencies such as curiosity, creativity, critical thinking, and an ability to work with people who have different perspectives are necessary (National Research Council, 2012). With an estimated 20.6 million students enrolled in US college and universities, many students, regardless of their majors, take at least one introductory STEM course as an undergraduate as part of their general education course requirements (National Center for Education Statistics, 2015). Therefore, STEM disciplines have a unique opportunity and responsibility to ensure that all students, regardless of their future career paths, gain the basic STEM competencies needed to learn about and address the daunting challenges of the 21st century (American Association for Advancement of Science,
Literature Review

To further understand the STEM education crisis in the US and the related imperatives for its improvement in relation to the rationale for and situate my current study, I deemed it necessary to review literature in three areas. First, I reviewed the literature insight into the impetus for change in postsecondary STEM education, alongside the potential solutions and challenges in making progress, with enhanced focus on the role of research universities in the US. Next, I examined the recent nationally recognized postsecondary STEM education improvement initiatives, particularly paying close attention to the underlying assumptions and theories of actions regarding change to undergraduate STEM education. Then, I reviewed the literature that highlights concerns for undergraduate students’ perspectives on educational practices and improvements, including how students’ perspectives, particularly on teaching, are commonly gathered and the limitations associated with such methodologies.

Transforming the Undergraduate STEM Classroom: Impetus and Calls For Improved Teaching Practices At Research Universities

Poor teaching practices and unsupportive, unwelcoming environments in STEM classrooms are major reasons why students, particularly from underrepresented racial and ethnic groups, leave STEM before undergraduate degree completion; even those students who graduate with a STEM degree express dissatisfaction with the teaching they encounter in STEM courses (Seymour & Hewitt, 1997; Seymour, 2001; Strayhorn, 2015; Watkins & Mazur, 2013). Concerning the undergraduate level, most students who leave STEM fields do so during the first or secondary year rather than later in their college career (Kober, 2015; PCAST, 2012). Recognizing the great imperative in preparing a highly skilled technical workforce and science-literate populace for the United States, government leaders, policy makers, and postsecondary administrators have shown an enhanced focused on promoting undergraduate STEM education improvement (Baldwin, 2009).

But how to improve undergraduate STEM education? Research continues to document that “traditional” practices of teaching and learning, which typically involve instructors delivering factual information to a passive audiences of students, fail to foster STEM knowledge and skills understanding, and that this failure contributes to the loss of interest in STEM fields
Based on decades of corresponding research regarding how students best learn in these disciplines, numerous studies and policy reports published in recent years have explicitly advocated for the adoption of student-centered active learning educational practices, shown to improve engagement and retention in undergraduates (e.g., Handelsman et al., 2009; Freeman et. al., 2014; National Research Council, 2012). Student-centered instruction is characterized by active learning techniques that engage students in the learning process (Felder & Brent, 1996; Machemer & Crawford, 2007; Prince, 2004). Active learning “requires students to do meaningful learning activities and think about what they are doing” (Prince, 2006, pg. 223). These instructional practices acknowledge the constructivist view in securing more meaningful and longer lasting learning via students’ active engagement with the content through teacher-facilitated practices such as discussion, hands-on activities, and problem solving (Felder & Brent, 1996; Fink, 2003; Paulson & Faust, 2008).

Although assumed by others as such (Freeman et al., 2014), these instructional techniques do not diminish the need for lecture as a practice; discipline-based science education researchers Graham, Frederick, Byars-Winston, Hunter, and Handelsman (2013) suggest a meld of “brief lectures interspersed with opportunities for students to reflect on or apply their own knowledge induces active engagement in large lecture courses” (p. 1456). A growing body of research suggests that student-centered, active learning techniques are linked to a variety of positive outcomes for students, including increased motivation, enhancement of critically thinking skills, long-term retention of information, improved exam performance, and increased persistence as STEM majors (Bleske-Rechek, 2002; Freeman et al., 2014; Kober, 2015; Handelsman, et al., 2004; Prince, 2004; Yoder & Hochevar, 2005). Examples of active learning techniques that have been confirmed to enhance student learning include peer instruction (Crouch & Mazur, 2001; Mazur, 1997), problem-based learning (Anderson, Mitchell, & Osgood, 2005) and use of clickers for frequent formative feedback regarding learning to both teachers and students (Smith et al., 2009; Martyn, 2007; Novak, Patterson, Gavrin, Christian, & Forinash, 1999).

Consequently, student-centered active learning has received considerable attention over the past several years and has been advocated by many education researchers as a means to improve teaching and learning in the undergraduate STEM classroom (Chi, 2009; Kober, 2015; Freeman et al., 2014; PCAST, 2012; Prince, 2006; Weiman, 2014). In addition, many
professional organizations and disciplinary societies to which STEM faculty belong, such as the Accreditation Board for Engineering and Technology and the American Chemical Society, have acknowledged the urgency to improve undergraduate STEM education and have specifically pressed educators towards shifting to these evidence-based practices to improve teaching and learning (Baldwin, 2009). As well, several postsecondary STEM education improvement initiatives advocating these instructional practices have been launched at many colleges and universities to improve the quality of undergraduate STEM instruction. Some of the most well-recognized initiatives include the Seven Initiatives developed by The Howard Hughes Medical Institute (HHMI)-supported biochemist research professors (Anderson et al., 2011); the Science Education Initiative developed by the Nobel Physicist, Carl Weiman (CWSEI) and his colleagues (Wieman, Gilbert, & Perkins, 2010); and the five-year nation-wide STEM education initiative launched in 2011 by the Association of American Universities (Association of American Universities, 2011)). Together, these powerful initiatives and influential organizations serve as catalysts for institutions of higher education to encourage and support STEM faculty to make a paradigm shift to more student-centered active learning instruction (Bouwma-Gearhart, 2011).

A plethora of federal, foundational, and institutional funding have generated significant improvement efforts on many campuses to improve undergraduate STEM teaching (Baldwin, 2009; Fairweather, 2008). Yet it has been claimed that the campuses that have been quickest to respond to calls for improvement, via both curricular and pedagogical transformation, are liberal-arts colleges; in comparison, progress at research universities (RUs) has been slow, sporadic, and extra challenging (Baldwin, 2007; Katkin, 2003). Specifically, evidence-based student-centered active learning instructional approaches have not yet become the norm in undergraduate STEM education at RUs despite documentation of effectiveness (Association of American Universities, 2011). Reasons for this lag at RUs are complex and multifaceted; yet one of the barriers most often cited is an unfavorable culture in STEM departments/programs for undergraduate education reform (Baldwin, 2009; Fairweather, 2008). While postsecondary administrators, education researchers, and even educators emphasize the critical importance of transforming education to support the success of students, departmental polices value and reward research output and abilities over teaching effectiveness, particularly in STEM disciplines (Association of American Universities, 2011; Fairweather, 2008; Savkar & Lokere, 2010). Simply put, in
today’s highly competitive environment to publish research and to secure external research funding, STEM units and their faculty fear an emphasis on (improvements to) teaching, less “counted” in the race for prestige in which the winners are determined by their research-focused accomplishments (Brainard, 2007).

**Undergraduate STEM Education Improvement Initiatives: A Focus On Transforming Departmental Culture Via Faculty Schemas, Practices, and Organizational Structures and Routines**

**Initiatives’ Theories of Action.** I use the term *theory of action* to refer to an initiative’s set of underlying assumptions about both what and how to improve regarding undergraduate STEM education. Focus at RUs center on changing current teaching practices, as detailed above. First alluded to in the above section, an assumed target of many initiatives is the lack of and adoption of evidence-based student-centered active learning practices, largely attributed to the academic culture at RUs that largely values research productivity at the expense of teaching effectiveness (Baldwin, 2009; Fairweather, 2008). I use the term *culture* to refer to the explicit and implicit norms, values, and behaviors that are normative within RU STEM education settings in the US (National Research Council, 2008). When we look across many recent STEM education improvement initiatives, a general theory of action emerges that involves the following assumption, strategies, and intended outcomes: 1) Evidence shows that student-centered active learning instructional practices help all undergraduates to learn disciplinary content and processes at a deeper level. 2) If we change the culture in postsecondary STEM education organizations (e.g. departments, colleges) to recognize educating students well as equally valuable to generating disciplinary knowledge and related publications and external funding, 3) then educators will more likely attempt to learn and use student-centered active learning practices. 4) These changes will be evident in faculty members’ changed teaching practices, as well as underlying mental constructs regarding teaching and learning (schema), their commitments and motivation to teaching and teaching improvement, alongside equally important changes to organizational routines (e.g. tenure discussions) and artifacts (e.g. promotion policies).

I now turn to detailing three representative undergraduate STEM education improvement initiatives, to both highlight their intentions in systematically facilitating change but also, and
most importantly for set the stage for my study, raise awareness to the minuscule attention these initiatives place on students’ perspectives. Although student performance and degree attainment are the ultimate intended outcomes of such initiatives, students’ perspectives, for the most part, have been woefully considered. Note that while the STEM education improvement literature includes documentation of a host of efforts aimed at improving undergraduate success, I selected the three initiatives below for their degree of recognition as initiatives targeting STEM education improvement at RUs in the US.

**Science Education Initiative (SEI).** The *Science Education Initiative (SEI)* was created by the Nobel physicist, Carl Weiman, and his colleagues in 2007 (Weiman, Perkins, & Gilbert, 2009). The SEI model has been implemented and evaluated at several RUs across the US and Canada. Central to the SEI model is the notion that any attempt to change teaching and learning environment can only be successful and sustained when the culture of the department is the central focus of transformation (Weiman et al 2009). The SEI model was developed based on the following assumptions: 1. Data are essential to convince STEM faculty to alter their teaching practices, 2. Both the department and individual faculty involved must have well-defined incentives and should be rewarded for change, 3. The process of change should not require additional financial investments as faculty design and assess new courses and learn to teaching in alternate ways, 4. Effective education innovation requires the focus to be on what the students learned rather than what and how faculty teach, and, 4. Transformation of teaching should take place in alignment with the transformation of the surrounding culture (Weiman et al., 2009; See website for more information: http://cwsei.ubc.ca/about/index.html).

**HHMI-supported professors’ seven initiatives.** Another prominent example of an STEM education improvement initiative was developed by a group of biochemist research scientists who received support from HHMI for creating new programs to increase student engagement in STEM (Anderson et al., 2011). As a result of their work related to improving STEM education for all students, these professors, research scientists, established the following *seven strategies centered on changing culture in STEM disciplines at RUs:* 1. Educating faculty about research on learning, 2. Rewarding faculty for effective pedagogy, 3. Requiring excellence in teaching for purposes of promotion and tenure, 4. Providing support for effective teaching practices, 5. Bringing together faculty to discussion teaching and learning issues, 6. Encouraging cross-disciplinary collaborations to draw upon the expertise from other departments including those
from Colleges of Education, and finally, 7. Engaging administrative and program leaders such as chairs and deans to promote the process of changing culture and improve teaching practices (Anderson et al., 2011; See website for more information http://www.hhmi.org/news/hhmi-professors-suggest-strategy-change-culture-science-education).

**Association of American Universities (AAU) STEM education improvement initiative.** More recently, the Association of American Universities (AAU), comprised of 60 U.S. and two Canadian RUs, launched a five-year initiative in 2011 to improve the quality of undergraduate teaching and learning in STEM fields at its members’ institutions. This large-scale initiative, just like the initiatives established by Anderson et al (2011) and Wieman et al (2009), is primarily focused on changing the culture in STEM departments at RUs. The underlying framework of the AAU STEM Education Improvement Initiative proposes that three key elements need to be addressed in tandem to drive sustainable change in postsecondary STEM education organizations. The first, *pedagogy* refers to methods and practices of teaching and involves key elements such as articulation of learning goals, evidence-based educational practices, assessment of learning, and creation of inclusive learning environment. The second factor, *scaffolding*, refers to the support systems available for faculty to help them advance their learning of evidence-based teaching practices and modification of teaching methods, including those granted by administrators such as department chairs, faculty professional development opportunities, resources and material to support the implementation of alternative teaching practices, and the use of data such as student retention in STEM majors to drive decision-making. The third factor, *culture change*, emphasizes the need for the commitment and involvement of the leadership at all levels of the institution including departments, federal and business and industry partners and disciplinary societies, working together in coordinated fashion to facilitate culture change and bring about sustained improvements in postsecondary STEM education (AAU, 2011; See website for more information https://stemedhub.org/groups/aau/framework).

**Initiatives’ inattention to students’ perspectives.** All three initiatives’ propose to foster improvement in STEM education via culture change, requiring the commitment of various stakeholders to drive change in STEM departments and colleges. In addition to having in common some facets underlying their theories of change, these initiatives draw little attention to students’ perspectives. Although the ultimate concern addressed by these initiatives is improving
student outcomes, they fail to explicitly mention if students have a part to play in the process of culture change. The initiative developed by with HHMI support, for instance, explicitly reports on the critical importance of the role and perspectives of the leadership in achieving culture change and improving teaching (initiative 7), but seems to overlook the critical importance of students in re-shaping the culture.

The creators of the SEI model noted that one of the lessons learned as a result of the implementation of the model was that the types of data needed to convince faculty to change their practices mattered; in particular, they documented that research and data on student learning were not compelling enough by themselves to change faculty members’ instructional practices, especially when that change suggested to them did not align with their personal beliefs about teaching and learning (Weiman et al., 2009). In addition, they noted that faculty value data on student learning collected from students enrolled in STEM courses in their within their respective institutions (Weiman et al., 2009). But beyond this small consideration of information from students, the SEI pays scarce attention to student input into improving undergraduate STEM education.

One of the main goals of the AAU initiative is to support the development of tools to survey and assess the quality of teaching and learning, specifically to examine the extent to which effective teaching methods are being used in STEM courses and effects of improved teaching on student retention and degree completion (AAU, 2011). To measure the effects of their improvement framework the initiative suggests departments to collect feedback from students via longitudinal surveys to understand their experiences in STEM fields (AAU, 2011). While the AAU initiative acknowledges that evaluating and testing the effects of their framework is a critical aspect of improvement in STEM education, their suggested methods of assessment fails to include students’ perspectives in a more direct form, during the planning and implementation phase of the improvement efforts during which their unique and authentic perspectives may be even more critical and necessary.

**The Potential Value of Students’ Perspectives On Educational Practices and Improvement**

If the ultimate desired outcome of improvement initiatives is to foster student success, their long-term learning and persistence in STEM, then the popular emphasis on leadership and faculty commitment to facilitate culture change must be counterbalanced with insights gathered from those who are ultimately the end recipients of such potential change, the students. My
concern for the lack of attention given to students’ perspectives in the decision-making and strategic planning of education improvement initiatives is exemplified by a letter, published in the *Science* journal, written by a senior undergraduate student in response to the Seven Initiatives developed by HHMI-supported professors, all research scientists. In his letter, Mike Torchia (2011) wrote,

As a senior undergraduate student at a large public research university, I agree with W. A. Anderson *et al.* (2011) that excellent teaching and research are not mutually exclusive pursuits. However, engagement with the students themselves is nowhere to be found in the authors' seven initiatives. Students—the largest stakeholders in the current landscape of science education reform—should be added to the list of chairs, deans, and presidents as parties to engage in the policy debate (initiative 7). Such an addition would add a fresh perspective on the issue, open valuable communication pipelines between students and policy-makers, and provide opportunities for students interested in educational policy to gain experience in the field. Restructuring the culture of education at research universities will require a new paradigm: Students should be considered not as passive consumers but as active participants in their education (p.858).

As highlighted in this letter, the perspective of students are often not explicitly considered in discussions and decisions about educational practices and change at the postsecondary level. In fact, students rarely have the opportunity to openly express and discuss their perspectives on and experiences in higher education. I argue that students have a significant stake in the education system, specifically in terms of their time commitment, finances, intellectual development and professional careers. They are the primary recipients of higher education who are directly influenced by the success or failure of the education system. As stakeholders and recipients of higher education, students have the potential to be a valuable resource in all phases of STEM education improvement efforts, not just as providers of data regarding an initiative’s efficacy, but additionally in its proposal, visioning, planning, and implementation. As experts in their learning experiences, students, just like faculty members and administrators, have the ability to identify problems and deficiencies in education, and determine possible solutions and strategies to improve education (Cook-Sather, 2002). At a time when increasing college accessibility and degree attainment has never been more important to the nation’s economic competitiveness and social well-being, who better than students to describe the college
experiences as well as identify what works and does not work, and why?

Cook-Sather (2002) presents a compelling argument for why students’ perspectives should be considered and used to inform critical conversations about education and reform:

As the pace of life accelerates, as the population becomes increasingly diverse, and as the media through which we teach, learn, and work become more complex, more than ever before, those of us who count ourselves educators and educational researchers must seriously question the assumption that we know more than the young people of today about how they learn or what they need to learn in preparation for what lies in the decades ahead (p. 37).

As well, as Lea, Stephenson, and Troy noted, “If education is to be truly student-centered, students should be consulted about the process of learning and teaching” (2003, p. 321). Considering students’ perspectives is essential because of the various ways they can improve education practice, inform existing conversations about education transformation, re-inform existing conversations, and also identify discussions and reform effort yet to be implemented (Cook-Sather, 2002). Similarly, Levin’s (2000) arguments on the involvement of students in education reform, although in the context of the K-12 sector, provides justification for the importance of counting students as valuable resources in the planning and implementation of reform work. His arguments included the following: “Effective implementation of change requires participation by and buy-in from all those involved, students no less than teachers; Students have unique knowledge and perspectives that can make reform efforts more successful and improve their implementation” (p.156-157). A better understanding of educational practices from the perspectives of those who ultimately experience these practices, the students, can spark new discussions of educational practices, or re-inform existing discussions, and consequently advance the work of improvement initiatives (Cook-Sather, 2002). I accept that nation-wide undergraduate STEM education improvement efforts will be more successful when students’ perspectives are recognized and considered in defining, planning, and implementing change in higher education.

While it is important to recognize and consider student perspectives, it is also important fully acknowledge that some students’ preferences and expectations may be unrealistic and, thus, require careful consideration. In some cases, it may be not possible to address preferences and expectations within the context educational context due to pedagogical or resource limitations
(Sander, King, & Coates, 2000). However, as Lea, Stephenson, and Troy (2003) pointed out, sensitively managing students’ preferences and expectations, even those deemed unrealistic, is still an essential part of the process of building a suitable teaching and learning environment that is conducive for all students. In spite of such challenges, I accept that educators should still do their best to make sure students have been recognized and heard.

By advocating for the importance of considering the student perspective, I am not implying that their perspective is the only one worth taking into account. The role of faculty and their perspective on teaching and learning is incredibly significant. There has been a growing body of research emphasizing the meaningful role of faculty, and this research strongly advocates for the importance of listening to and responding to faculty needs and expectations as an essential means of achieving sustainable change and improvement in undergraduate STEM education (Bouwma-Gearhart, 2012; Fairweather, 2008; Dancy & Henderson, 2008; Hora, 2011). In fact, most STEM education improvement initiatives, including those described earlier in the section, are centered on faculty and instructional change. Dancy and Henderson (2008) advocate for the key role of faculty by claiming “we do not expect any reform effort to be successful unless it involves faculty as meaningful participants” (p. 11). Similarly, Hora (2011) claims that it is essential to highlight the instrumental role of individual faculty members in educational improvement efforts because, ultimately, they are the ones that adopt or reject new policies and interventions based on their own expectations and experiences, local climate, and pressures that influence their classroom practice.

My intention to bring the students’ perspective into the larger conversation on improving STEM teaching does not seek to minimize or overlook the key role of faculty and their contributions but to encourage and promote the notion that the complex activity of teaching is best understood from multiple perspectives including both faculty and students (AAAS, 2012; Hora & Ferrare, 2014). The American Association for the Advancement of Sciences (2011) acknowledge that information gathered from students could contribute critical insights into undergraduate STEM teaching, and they call for more research to explore the kinds of questions and response formats that yield the most useful and constructive information. To better understand “what works” in undergraduate STEM teaching practices, the AAAS (2012) also suggests that researchers need to conduct in-depth studies to investigate student experiences in STEM classrooms. I contend that it is equally important to consider both the student and faculty
perspective to build an overall well-functioning education system (AAAS, 2012). I adopt Lea et al.’s (2003) perspective, who argued eloquently for consideration of both faculty and student perspectives to better understand the complicated nexus of education, involving the instructor-learner relationship, towards building better education experiences for all students:

The student’s view is a valid part of the negotiation between the instructor and learner. Such negotiation about the learning experience is crucial to maximizing success in terms of learning outcomes for all students, and not just the highly committed and exceptionally skilled minority (p.333).

Students’ Perspectives on Teaching and Learning In Higher Education: What Former Scholarship Tells Us

To advance the student perspective in undergraduate STEM education improvement, I reviewed literature on what is known students’ perspectives on teaching and learning in higher education, written in peer reviewed articles since the year 2000. In 2007, Machemer and Crawford discovered that scholarship on students’ perspectives on college teaching and learning is limited and presents conflicting information. Seven years later, I echo this sentiment. And very few of the already limited studies specifically explored the student perspectives of teaching and learning specifically in STEM disciplines (e.g., Welsh, 2012; Lake, 2001). In the sections below, I review and discuss previous work, summarizing students’ view and perceptions of postsecondary teaching and learning specifically in STEM courses, as well as approaches employed to elicit their perspectives.

Students’ preferences for teaching methods: Lecture vs. active learning. Much of the previous work on postsecondary students’ perspectives on teaching and learning in STEM is largely focused on examining students’ preferences for teaching methods, typically framed within a dichotomy, as either lecturing or active learning. For instance, Covill (2011) studied college students’ perceptions of the “traditional” lecture method, akin to the instructor talking about content and processes while illustrating with text and words via PowerPoint presentations, with students encouraged to take notes throughout. The instructor of the course studied did not provide students with note outlines for lectures. In this quantitative descriptive study, 51 students in the introductory level psychology course (psychology is deemed a STEM subject per the National Science Foundation) completed a self-report survey that included 13 Likert scale type questions related to how much they learned in the course (e.g., “I feel I learned a great deal in
this class’); sources that influenced their learning, including peers, textbooks, and the instructor (e.g., “I relied on the professor to give me the information I needed to know in this class”); and their rating for the course and instructor, which was based on how they learned (e.g., “Based on how much I learned, I would rate the professor of this class as…”). These 51 students also filled out an end-of-semester course evaluation from which the following three items were used to inform Covill’s (2011) study: (a) number of times instructor encouraged independent thinking and problem solving, (b) number of times instructor encouraged engagement during class time, and (c) whether or not the course helped students in their ability to apply course material. Covill (2011) found that a significant number of students strongly valued the traditional lecture style. In addition, students reported that they felt engaged during class time, learned a great deal throughout the semester, and would be able to retain the material for a long time. A majority of the students (above 70%) perceived that the instructor “almost always” facilitated independent thinking, problem solving, and involved students in the learning process. Based on these findings, Covill (2011) concluded that students perceived traditional lecturing as an effective teaching practice that produced positive outcomes such as engagement, independent thinking, problem solving, and long-term retention of material.

In contrast to Covill’s (2011) study, Lake (2001) studied student perceptions of course and instructor effectiveness with 170 students enrolled in three sections, one “lecture” section and two “active learning” sections, of a physiology course taught by the same instructor. Active learning, in Lake’s (2001) study, was defined as having reading assignments combined with a discussion of that reading assignment without the benefit of a series of lectures that comprehensively covered all topics in the course. Students in the active learning sections were instructed to read new material, followed by a class period of “lecture,” similar to the control section, in which the instructor discussed only those topics with which students in previous terms had the most difficulty understanding from reading assignments. Students in both courses received the same weekly quizzes and exams, and the same course topics and readings were presented in both courses. Results on course grades indicated that the academic performance of students was higher in both active learning sections compared to the lecture section, yet students in both active learning sections felt that they had learned less than students in the lecture section. As well, student perceptions of the course, overall, and instructor effectiveness were lower in the active learning sections than in the lecture section. There were no differences between the lecture
and active learning sections with respect to students’ perceptions of course difficulty. The lower satisfaction students expressed for the active learning sections of the course may have been influenced by the size of the discussion groups. Lake noted that each group included 15 to 20 students, viewed as problematic by some researchers in favor of a maximum of six students in active learning groups (Argyle, 1972; Goldschmid & Goldschmid, 1976; Rangachari, 1995). To address the problem of student perception of active learning in the classroom, Lake (2001) suggests that “the threshold of student acceptability might be between 25% and 50% for active learning assignments” (p. 901) and therefore recommends the incremental introduction of active learning methods in courses to help students accommodate to this new learning style.

The two active learning sections in Lake’s study also differed in one significant feature: in one, the rationale for active learning methods was discussed, whereas in the other, the rationale was not discussed. In comparing the two sections, Lake found that student perceptions regarding perceived course effectiveness were higher in the “rationale” section, but there were no differences in perceptions regarding instructor quality and amount learned. Even in the section where the rationale for active learning methods was discussed, the students’ perceptions of course effectiveness and instructor effectiveness continued to be lower than the perceptions of students in the lecture course.

Machemer and Crawford (2007) conducted a quantitative study to examine how students enrolled in an upper level Integrative Studies in Social and Behavior Sciences (ISS) course perceived and valued the following three types of learning used in this cross-disciplinary course: active, cooperative, and traditional learning. The broad topic covered in the course under investigation was “People and the Environment.” The class was scheduled twice per week for two hours each day. Each week, the first class involved just lectures and the second class involved active learning activities. Specifically, activities that required independent active learning were categorized as just active and those that group cooperation was categorized as cooperative. The lecture format that involved the instructor lecturing using PPT slides was categorized as traditional lecturing. The survey results, completed by 343 students, indicated most students valued active and traditional learning equally when compared to cooperative learning activities. Based on the students’ perspectives, cooperative learning (i.e. working in groups) was rated the lowest. Machemer and Crawford (2007) found that “values significantly decreased when the students are asked to work in groups with cooperative expectations or
requirements” (p. 24). The authors reported that even though students valued being active in the classroom, they did not enjoy working in groups. Similar to Lake’s (2011) study, Machemer and Crawford broadly examined student perceptions of active learning compared to the traditional lecture format of instruction. Both these studies found that students expressed dissatisfaction with active learning in form of group work but did not provide any in-depth understanding as to why students disliked this form of active learning.

Welsh (2012) explored students’ perceptions of active learning techniques as part of her larger study focused on factors influencing students’ academic performance in math and science. For this study, Welsh’s framed active learning techniques as engagement with tools, such as clickers, or activities, such as group discussions, that engaged students in class, as well as provided students feedback. In the survey completed by 492 students, Welsh asked students to rate how influential active learning techniques were for their learning. This question was framed broadly with no specifics about the types of active learning techniques that were being assessed. Overall, student perceptions were mixed. Of all 492 student participants, 30% of students perceived in-class active learning techniques as an unimportant or slightly important factor influencing their academic performance. Another 30% perceived such techniques as a somewhat important, and the remaining 40% perceived active learning techniques as important or very important. Welsh’s survey also included an open-ended response question that asked students to elaborate on their perceptions of active learning. Most common negative comments included the assertion that group work was waste of lecture time, and clickers were a waste of money since they were mostly used to track attendance. However, the most common positive comments also discussed clickers and group work. Specifically, students expressed that clickers helped them stay engaged and receive feedback on their understanding of the material. Positive student comments about group work indicated that group discussion made students feel like they were part of a community and gave them opportunities to hear different points of view on a certain topic. In addition to the positive and negative comments, some students expressed that regardless of the type of active learning activity, how effectively the instructor implemented the active learning techniques influenced whether or not the techniques promoted student learning and understanding (Welsh, 2012). Welsh’s (2012) study is unique among the studies reviewed in this section in that it included an open-ended question to give students an opportunity to describe in their own words their perceptions and opinions of active learning. The information gathered
from the results of this open-ended question were more nuanced and gave students an opportunity to express how various types of active learning activities, specifically clickers and group work, influenced their learning and engagement.

**Methodological limitations.** Several higher education researchers have made the compelling argument that active learning related pedagogies do in fact better support student learning outcomes in postsecondary STEM courses. However, based on my review of previous research studies primarily focused on examining postsecondary STEM students’ perceptions of active learning and/or lecturing, I found that there is no clear consensus on student preferences for certain methods of instruction, partially based on methodological limitations of the studies themselves. First, there is no standard conceptualization of the so called “traditional” lecture method and as a result active learning pedagogical techniques which is typically presented as an alternate to lecturing is also conceptualized in many different ways. For instance, although Covill’s (2011) work sheds some light on student perspectives about lecturing, the criteria Covill used to classify courses as traditional lecture-based courses raises several methodological concerns. In the description of the course format and teaching practices for courses designated as “traditional lecture-based courses” Covill includes the following criteria: the instructor’s lectures were supported by PowerPoint slides; once or twice during every class session the instructor posed questions to the students and gave students an opportunity to respond; and students were required to complete five handouts that included exercises designed to reinforce concepts, three of which were completed during class time and two outside of class time. Covill (2011) also asserts that “minimizing the use of active methods was done in order to test as pure a version of the lecture method as possible” (p. 92). Based on how most education researchers conceptualize differences between the traditional lecture-based and active learning techniques, a *pure version of the lecture-based method* typically involves the instructor continuously talking while the students are passively listening (Felder & Brent, 1996; Hora, 2014). Besides the minimal use of active methods, it seems to appear that the course instructor incorporated the regular use of technology via PPT presentations and student-teacher interactions via questioning strategies, two features of practice that are shown to promote learning and engagement (National Research Council 1999, 1999; Kober, 2015). Therefore, the author’s description of the course as purely traditional lectured-based seems overly simplistic and potentially inaccurate as it ignores other features of the instructor’s practice, such as the
instructor’s questioning strategies and use of technology, that are essential to consider when describing teaching.

While Covill’s (2011) study framed the lecture method as the instructor lecturing using PPT with minimal use of questioning techniques, Lake’s (2001) study framed the lectured method as an instructor talking continuously without using any additional strategies of techniques, during one class period per week that met twice a week. Yet, both Covill (2011) and Lake (2001) consider their conceptualization of lecturing as the traditional method of instruction that contrasts active learning. These various versions of the framing of lecturing makes it difficult to determine what researchers actually mean by “traditional” lecturing (Hora, 2014). Therefore, it is difficult to make a generalized claim regarding the most effective practice from the perspective of students. Second, as Machemer and Crawford (2007) already point out, past studies compared various forms of instructions including active learning versus lectures across a variety of courses classes, attending to different STEM disciplines, with different instructor and different students. This observation adds to the concern of not being able to discern precisely the most effective form of instruction based on students’ perspectives.

Regardless of how lecturing and active learning have been operationalized, what I find even more concerning is the fact that much of the previous work focused on students’ perspectives about teaching and learning used structured surveys and other forms of questionnaires through which students were asked to rate or rank a specific teaching style(s) (e.g., Carpenter, 2006; Covill, 2011; Machemer & Crawford, 2007; Lake, 2001; Welsh, 2001). Quantitative methodological approaches such as surveys can be one of the most time efficient and convenient ways to learn about a general trend in people’s opinions, experiences, and behavior, and are particularly useful to gather small amounts of information from a larger and wider selection of individuals in hopes of making a general claim (Creswell & Clark, 2007). However, surveys are not well suited to capture rich data concerning more nuanced perceptions of a topic, especially those as complex as teaching and learning (Creswell & Clark, 2007). The use of surveys allows researchers to only provide fixed response categories that are based on their own personally biased perspectives and predetermined criteria; any response that falls out of their criteria cannot be captured (Creswell & Clark, 2007). An important methodological concern related to the studies discussed above is that the survey questions used to capture student perceptions were too general and asked students about their overall experience in the course, not
just when the instructor was lecturing. All survey questions relied on self-report on the part of students, with no other metrics used to ascertain learning and engagement. Thus, the conclusion that students learned a lot, felt engaged, and were able to independently think as a result of the traditional lecture method is questionable, since throughout the course students also encountered other forms of practices, such as hands-on exercises, that could have contributed to their learning.

In addition, the surveys used in most of the previous studies were based on simplistic conceptualizations of teaching practices and learning responses that reduced these complex phenomena to just a method of teaching used in the classroom—specifically “active learning” or “traditional lecture-based” methods—and a certain learning response or related preference. No other components of teaching and features of the classroom environment that could have also influenced students’ learning and engagement in the classroom were captured via these surveys. With the exception of the study conducted by Welsh (2012), student respondents of these surveys were forced to make categorical choices without any opportunities to elaborate on whether and how certain aspects of active learning or lecturing were more meaningful (or not) for their learning.

At a time when improvement of undergraduate STEM instruction is a top national priority, I acknowledge the valuable contributions of several education researchers who have gathered students’ perspectives on various aspects of their undergraduate experiences (e.g., Covill, 2011; Machemer & Crawford, 2007; Welsh, 2012). I also acknowledge the many institutions of higher education who place great emphasis on gathering data on students’ perspectives, albeit primarily, and limitedly, in form of feedback such as course evaluations (Marsh & Roche, 1993) or, less typical, the National Survey of Student Engagement (NSSE) (Kuh, 2001), itself reliant on too simplistic conceptions of teaching practices. In fact, the most popular method used by institutions, as with researchers, to gather students’ perspectives involve questionnaires and surveys. While such quantitative data collection approaches commonly used in higher education provide broad insights on the perspectives of students, such processes often do not provide a sufficiently clear and specific data, nor baseline data for the planning of teaching or related improvements (Lizzio, Wilson, & Simmons, 2002). I argue that to better support undergraduate STEM improvement efforts, researchers and institutions must gather richer student accounts of teaching and their learning, accounts that go beyond simple ratings of
preferences for “active learning” versus “traditional lecture” teaching methods.

I contend that higher education researchers, as well as postsecondary education administrators, policy makers, and faculty can all benefit from richer and more nuanced data of student perspectives of teaching and learning, to both advance understanding of current practices and foster related improvements. Research studies that employ more open ended approaches in which students are given opportunities to share their perspectives on teaching and experiences in STEM courses in a more direct and candid manner is warranted to gain a more holistic understanding of current educational practices in STEM education, specifically concerning teaching practices that are perceived as affordances for students’ learning and persistence in STEM courses and programs. I believe the methodology of my research study begins to meet the need for deeper exploration and understanding of the complex phenomena of teaching and learning from the perspective of students.

**Guiding Framework: Students’ Sensemaking Regarding Perceived Affordances and Constraints Concerning the Educational Environment**

I root my study concerning students’ perspectives on undergraduate education at RUs, generally speaking, and teaching practices in STEM courses, specifically, in Gibson’s school of thought known as *ecological psychology*, rooted in an organismic view or reality. Gibson posits that an individual’s actions (including learning and engagement) cannot be studied in isolation from the individual’s environment (Gibson, 1979). In fact, the “world,” as conceptualized by Gibson, consists only of those things perceived by individuals in its environment (Gibson, 1979). Central to Gibson’s (1979) view of the world is the concept of *affordance*, or the opportunities for individuals’ actions based on their perceptions of the environment. According to Gibson (1979), “the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill” (p. 127). Gibson’s concept of affordances is rooted in a sensory perception of the natural world (hence the term ecological psychology). Gibson’s affordances is best illustrated by Sadler and Given’s (2007) description of how a rock is perceived by a reptile and a human:

A reptile in a desert might perceive a large rock as a place to sunbathe or a place to hide; a human might perceive the same rock as a weapon or a building material. There is no “correct” use for the rock, only the affordances perceived by various perceivers (p. 117).
This relationship between organisms and the environment lies at the heart of the concept of affordance (Sadler & Given, 2007). However, a noted deficiency of affordance theory is a lack of attention to how an organism makes sense of an affordance. I thus also rely on the theory of sensemaking which stipulates that organisms (including humans) situate perceptions of affordances in preexisting mental constructs (schemas) that have been themselves constructed via their experiences with other environmental affordances (Letiche & Lissack, 2009).

Applied to the context of my study, the affordances of the student’s education environment (the components of their STEM courses, including classroom environment) are what the students can perceive as potentially useful or deleterious for their learning and persistence in STEM. I report grounded findings on affordances that students’ perceive as favorable to their learning and engagement in the classroom, including their perceptions of the specific characteristics of instructors, themselves, and other resources within the education environment that support their learning needs. In contrast to affordance, which I default to to describe factors described by students as having a positive impact, I use the term constraint to identify any quality of the educational environment that restricts students to perform an action, i.e. learning and engagement. In this analysis, I consider the perceived constraints of undergraduate education environments, generally speaking, as well as the perceived affordances of the undergraduate STEM environment, which taken together may be influential for students’ success in higher education.

Foci of the Current Study

Students’ perspectives are frequently overlooked during decision-making and strategic planning concerning undergraduate STEM education programming and practices, as well as regarding their improvement. I assume the notion that undergraduates are expert informants of their educational experiences who have perspectives that need to be considered in discussions related to educational practices and their improvement. My qualitative investigation sought to discover students’ perspectives of undergraduate education environments at RUs and students’ perceptions of the classroom environment in STEM courses specifically. Using semi-structured individual interviews and focus groups that involved 61 students across three RUs in the US and Canada, numerous themes emerged from these data. These included issues tangentially related to teaching practices, such as faculty members’ perceived lack of interest in teaching and unsupportive attitudes towards students, both perceived as a major constraint of the educational
environment at RUs. Students’ perceived affordances for their learning and persistence was deemed to be rather complex, extending beyond simple categorizations of teaching methods, such as lecturing or active learning. In addition to specific teaching methods (e.g., small group work), other affordances included a plethora of more general teaching methods (e.g., interactive lectures), instructional strategies (e.g., use of illustrations), students’ cognitive engagement opportunities (e.g., connections to real world), additional physical/technological resources (e.g., notes), and instructor personality traits (e.g., enthusiasm). Collectively, students’ perspective on affordances for better learning and engagement in postsecondary STEM education environments is best represented as a multi-dimensional phenomenon. Thus, this study adds student-specific confirmation to others’ calls to researchers and educators, alike, to recognize and operationalize teaching and learning as multifaceted phenomena to be examined along various dimensions and well beyond just teaching methods.

**Purpose and Research Questions**

My study intended to give students an opportunity to share, in their own words, their perspectives on the undergraduate STEM education environment at RUs, and to provide interpretation of their perspectives to the larger STEM education community, especially the subsection of this community committed to improving undergraduate STEM education. Drawing on theories of affordances and sensemaking, I sought to answer two primary, and interrelated, questions:

1. What are students’ perspectives on the undergraduate STEM education environment at research universities, specifically those they perceive as affordances/constraints regarding their academic success?

2. What are students’ perspectives on teaching in STEM courses, specifically those they perceive as affordances/constraints regarding their learning and engagement?

**Methodology**

**Background to a Larger Study**

This qualitative study is part of a larger multi-year NSF-funded research project, *Tracking the Process of Data-Driven Decision-Making in Higher Education (TPDM)*, that employed a mixed methods approach design to conduct to investigate data-driven decision making related to curriculum and instruction in STEM disciplines at RUs (details can be found on the project website: [www.tpdm.wcer.org](http://www.tpdm.wcer.org)). In particular, my study draws from data part of
Phase 1 of the TPDM project, collected spring of 2013 at three large, public RUs in the United States and Canada. These study institutions were selected based on their similarities in type, size of undergraduate student enrollment, research activity, external grants and funding, and accreditation requirements in the STEM disciplines (Carnegie Foundation for the Advancement of Teaching, 2014; Universities Canada, 2014).

Data collection procedures at each site were distributed across members of the TPDM research team, two Co-PIs and two project research assistants, respectively. My role as one of the project assistants was as a team member working in close collaboration with the other team members in the co-development of the research design, including recruitment of participants, co-development of interview protocols, and co-collection and organization of data. I was independently responsible for conducting all data analysis of student interviews pertinent to the study described in this dissertation paper (described further below), with mentorship from my doctoral advisor, Dr. Jana Bouwma-Gearhart, the Oregon State University Project Investigator of the larger TPDM project. As such, while the research design and data collection of the larger TPDM study was a team effort, the research questions, analyses, and conclusion-building detailed in this paper are of my independent undertaking. This study followed the appropriate human subjects’ procedures and requirements adopted by the research team’s primary institutions, and Institutional Review Board (IRB) approval at both universities was secured for this project.

**Researcher’s Ontological and Epistemological Assumptions**

Based on the primary aim of this study, the ontological stance of this research acknowledges the multiple realities of students that are shaped by their social and personal experiences. I assumed an epistemological stance anchored in the constructivist paradigm in exploring the generation of knowledge, understanding, and meaning around phenomena and research methods that acknowledge human interactions in shaping realities (Guba & Lincoln, 1994). Consequently, a qualitative methodological approach was best suited for this research. These perspectives resonate with my own beliefs about the world, the construction of knowledge, the value of subjectivity in research as well as my own commitments to improving education, including commitment to involve key stakeholders (student and faculty) in visioning and enacting education improvement activities.
Participants

The sampling frame for this study included undergraduate students enrolled in biology, geosciences, physics, and mechanical engineering courses at three selected RUs. To better understand the selection process employed to recruit student participants for this exploratory study, it is essential to detail the overall sample selection method employed for the larger TPDM project described above.

**Step One: Program chairs.** The first step in our participant recruitment procedure involved the identification of program chairs from the departments of biology, geosciences, mechanical engineering, and physics, to request their permission to proceed with the study in their respective department or program. The research team reviewed the selected departments’ websites to identify the chairs and sent each chair an email that included the description of the TPDM project, the goals of the study, and the types of data we planned to collect during our visit to the university (see Appendix A for the email message sent to chairs). All the twelve chairs that were contacted responded to our email and gave us permission to contact faculty members from their department or program for our study.

**Step Two: Faculty.** The second step involved the identification of instructors from each of the four STEM departments at the three research sites. We employed non-probability sampling procedure to select instructor participants for the TPDM study. Using each institution’s course listings website, we identified instructors from the departments of biology, physics, geosciences, and mechanical engineering who taught lower level undergraduate courses (400 or below). Then we contacted these instructors via email about one month prior to each site visit. The email contained necessary information regarding the purpose, requirements, and dates of our study (see Appendix B for the email message sent to instructors). In this same email, we also included brief information about the following types of data that the team planned to collect at each research site: (a) in-person faculty interviews focused on issues related to course planning and instructional practices; (b) classroom observations of two classes to capture teaching behaviors and student engagement using a web-based instrument (i.e., no videotaping); and (c)

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3 By the term “instructor,” I mean individuals who teach undergraduate courses at research universities, including full- or part-time, tenured or untenured research professors/lecturers. Throughout the rest of this paper I use the terms “instructor” and “faculty” interchangeably.
anonymous student surveys and student focus groups to gather information about study habits and classroom experiences.

We contacted a total of 151 instructors who taught lower level undergraduate STEM courses, and 56 ultimately expressed their willingness to participate in the study (37% response rate). The respondents represented the following disciplines: biology (n=18), geosciences (n=15), physics (n=11) and mechanical engineering (n=12). All 56 faculty participants expressed their willingness to be interviewed; however, only 52 participants gave us consent to observe their classes.

**Step Three: Students.** The third and final step (detailing the most important research participants for my research focus, the focus of this paper) included the procedure to recruit students for the larger TPDM project. During the week of each institutional site visit, we emailed the 52 interested faculty participants, who had previously given us permission to observe their classes, to request their willingness to help our team recruit students for focus groups. We only contacted those faculty members whose classes we had already observed because the student focus group discussion focused somewhat on the classroom experiences in the classes that one of the study team members had observed. Of the 52 instructors, 22 agreed to email their students about the TPDM project and detail opportunity to engage in focus groups. We provided the email message that the faculty participants sent to students. The email message included pertinent information about focus groups, including the purpose, date, time, and location. (See Appendix B for the focus group email message provided to instructors). This email also included information about the incentive to participate in focus groups. Students who participated in the study received ten dollars in cash as compensation for their time. Interested students emailed the member of the research team responsible for organizing focus groups sessions for that particular university. Although the initial design of the study included student data collection via focus groups, we had to conduct a few individual interviews at each research site due to low student interest or other students not showing up for their scheduled focus group. Focus group size ranged from two to six students. Overall, 13 focus groups and nine individual interviews were conducted, with each session moderated by one member of the TPDM project research team. Of all of the 21 focus or individual interviews, I conducted 9. The final sampling frame for this study included 61 undergraduate students enrolled in the selected biology, geosciences, physics, and mechanical engineering courses. However, it is important to note only a handful of the focus groups (n=5)
and individual interviews (n=8) sessions afforded time to discuss the question directly related to students’ perspectives on the STEM educational environment at RUs and only 25 of the 61 students were able to share their perspectives. Table 1 presents descriptive information about interview participants.

Table 1

*Undergraduate Student Sample Characteristics (N=61)*

<table>
<thead>
<tr>
<th></th>
<th>No. of Students</th>
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<tbody>
<tr>
<td><strong>Gender</strong></td>
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<tr>
<td>Male</td>
<td>28</td>
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<tr>
<td><strong>Field of study</strong></td>
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<td>26</td>
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<tr>
<td>Geosciences</td>
<td>12</td>
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<tr>
<td>Mechanical Engineering</td>
<td>12</td>
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<tr>
<td>Physics</td>
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<tr>
<td><strong>Level of course</strong></td>
<td></td>
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<tr>
<td>Lower</td>
<td>44</td>
</tr>
<tr>
<td>Upper</td>
<td>17</td>
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**Data Collection**

*Qualitative research methods.* Focus groups and one-on-one interviews are the most widely accepted techniques for collecting qualitative data (Creswell, 2012). While more quantitatively oriented methods of data collection reach a large number of individuals, qualitative research methods create a constructive opportunity for a researcher to interact with individuals and gather data on human behavior, opinion, and experience in more depth (Creswell, 2012). In their well-known book, *Talking about Leaving: Why Undergraduates Leave the Sciences*, Seymour and Hewitt (1997) described students as “expert informants who are well-
placed to describe the strengths and limitations of their educational experiences” (p. 13). This book is an in-depth report of a large, multi-institution study of undergraduate experience in STEM disciplines conducted over a three-year period by gathering data using in-depth interviews and focus group discussions with students. To support their findings, Seymour and Hewitt (1997) present a variety of student quotes that offer a glimpse into the lives, perceptions, and experiences of the students.

There are many benefits and strengths of using qualitative research methods, but one should also be aware of the limitations associated with these methods and their influence during data analysis (Denzin & Lincoln, 2011). Although qualitative research provides rich and valuable insights into the lives of individuals and their experiences, transcribing, coding, and interpretation of data is time consuming and labor intensive (Berg & Lune, 2011; Creswell, 2012). In addition, as I acknowledge about my own study, researcher bias and subjectivity are inevitable while interpreting qualitative data (Bogden & Biklen, 1997; Creswell, 2012). However, researchers can be mindful of their biases and I have attempted to minimize the influence of my biases while interpreting data (Bogden & Biklen, 1997). While conducting the analysis, I made reflective comments about my own suppositions and emerging judgments about the data. This reflective process enabled me to become aware of my own perceptions and experiences and how they might influence my interpretation of students’ responses. I was attentive to presenting the perspectives of participants themselves and not my own.

**Interview protocol and setting.** Each focus group and interview session was conducted by one of the team members at a specified location at each study site. Light refreshments were served. Each session began with the researcher providing a brief description of the project. Students were requested to sign a consent form that included a description of the study and the potential consequences of their participation (see Appendix D for student participation consent form); every attempt to protect their identities as research subjects was promised. Each session was audio-recorded, and the length of each session varied from 45 minutes to an hour.

Each TPDM research team member was involved in the development of the interview protocol utilized during the one-on-one and focus group interviews with students, and each team member underwent training to normalize how the team of four researchers would conduct interviews per the protocol. (See Appendix E for interview protocol.) A semi-structured interview technique was used for both the focus group and individual interview sessions, which
simultaneously allowed for participants to provide authentic accounts of their experiences and perspectives while maintaining consistent structure and order (Berg & Lune, 2011). The protocol included questions about participants’ quality and nature of their learning experiences in college generally and STEM fields as well as their perspectives on effective teaching practices and problems in undergraduate education. Although a standardized interview protocol and set of questions were used, the semi-structured format allowed interviewers to probe participants to elaborate further on their responses, and the discussion often became conversational (Berg & Lune, 2011).

For this study, two interview questions were most salient. This included: What are your preferences for how instructors should teach STEM courses and why? The question was framed broadly for two reasons: (a) to avoid constraining the characteristics of teaching that respondents might consider as part of their answer, and (b) to give respondents an opportunity to discuss teaching as affordances based on their own classroom experiences in college courses and how they learn. The other question was: Do you think that there is a problem with undergraduate education? This question is admittedly biased towards the negative/perceived constraints, but as a counterpart to a more positive first question.

**Data Analysis**

The audio recordings of interviews were professionally transcribed for analysis. Transcripts were stored electronically using NVivo®, a qualitative data analysis and management software. Project assistants read and re-read each transcript and segmented passages of text into manageable units that encapsulated various topics of interest (Miles & Huberman, 1994); passages of texts were tagged under primary codes labeled based on topics that guided the semi-structured interview with participants. For the purposes of the study presented in this chapter, I developed two coding reports that included segments of texts grouped under the primary code “perceived constraints” and “perceived affordances” both with respect to the STEM education environments.” These two coding reports served as the primary data source for subsequent analysis.

During my initial reading of each coding report—for which the goal was to gain general insights on student opinions, attitudes, and experiences immersed in the data—I wrote textual summaries, along the margins, that included key comments made by participants. Boyatzis (1998) notes that the process of paraphrasing or summarizing data allows information “into your
unconscious, as well as consciously processing the information” (p. 45). I then re-read the transcripts to generate initial categories of information resulting in a preliminary list of codes that represented “an initial plot of the terrain” (Miles & Huberman, 1994, p.69). This technique is known as open inductive analysis (Strauss & Corbin, 1994), with no preconceived codes; each code referenced a discrete idea conveyed via participants’ talk that I deemed indicative of their perspectives. Since participants often alluded to several issues in the same statement, segments of texts were often tagged by several different codes, each with a different name. It is important to note that even a single comment made by a single research participant as notable as those that were repeated or agreed upon by other participants. Next, I used the constant comparative method to closely examine codes, and I grouped similar codes that seemed to relate to each other under broad categories—and sub-categories, while leaving intact those that stood independent from all others (Glaser & Strauss, 1967).

Here I provide an example to illustrate my coding and sorting process. It was evident from reading the transcripts that many students perceived specific instructor lecture styles as affordances for their learning. Examples of basic codes that I created while trying to stay grounded in the data included “interactive lecture” and “lecture using chalkboard.” The coding process allowed for the grouping of these types of codes into one major theme, “lecture method.” Arranging similar codes into one category allowed me to conveniently compare the various types of lecturing that students perceived as affordances for their learning and, thus, preferred of their STEM instructors to implement in the classroom. This form of coding and categorization scheme was applied to all parts of the data to systematically analyze and interpret the data while also identifying overarching themes grounded in the concrete evidence provided by students’ accounts. In this study, for the questions concerning students’ perspective on constraints and affordances for their learning and engagement, four and five major themes emerged, respectively. These themes provide the basis for the final framework for discussing more nuanced findings and implications.

**Findings**

To reduce the length of this already long paper, I present a limited number of illustrative quotes from interview participants to demonstrate the evidence I used in synthesizing findings.

**Students’ Perceived Constraints In Undergraduate STEM Education Environments**
Four primary categorical patterns emerged as I analyzed the data, obtained from 22 of the 61 students participants, regarding issues related to students’ perceived constraints regarding their academic success: (a) faculty members’ teaching and teaching improvement practices and commitments, (b) class size and structure, (c) general education course requirements, and (d) academic advising. Table 2 presents a rank-ordered list of the categories, as expressed by at least three of the 22 student participants, which I now attend to in greater detail.

**Faculty members’ teaching and teaching improvement practices and commitments:** a perceived product of RU culture. The most commonly perceived constraint, expressed by more than half of participants in this study (n=11), concerned faculty pedagogical practices, often discussed as poor instructional practices. Students often waged this complaint alongside their larger perceptions of teaching, writ large, at RUs, stating perceptions that RU STEM faculty often do not value teaching and/or do not care about students, and therefore were not interested in putting in efforts to teach (more) effectively.

In one particular focus group, students discussed how the unfavorable RU culture, favoring research over teaching, does not value or reward faculty who are actually good at teaching. One student noted that at his university “Such a high emphasis on being a research university that often times professors are more valued for what they're contributing to their field rather than their teaching abilities. For example, I think that Dr. [X] who teaches general chemistry here, was by far the best teacher I've had.” Another student added, “I've also heard that he gets hassled for not doing more research. And so I feel like the emphasis is more on making a name for the school and making them stand out in some field or another rather than on professors who are really competent teachers.”

Students often linked such culture to faculty members’ prioritizing research over teaching, translating to lack of faculty time preparing for classes, as well as instructors’ negative attitudes towards students. The following quote from one participant captures the perception:

Because this is a research university, there are times like in a class that I'm having right now where the instructor is a working researcher, and that takes up a lot of their time. And teaching comes secondary to their own research. I mean they're putting so much effort into the research and often times their whole job depends on that research 'cause they're writing grants, and they need to get funding and stuff. So it's very understandable, and I can empathize with them, but it is frustrating to the students who don't get their
emails replied to and stuff and the instructor has all these excuses. Students talked about how faculty lack the motivation to improve teaching because of this unfavorable and unsupportive university culture. One student noted how prevalent the perception is that RU faculty do not have motivation to try to teach well, with “people told me over and over again, ‘go take this course at a community college, do whatever you can to not take it here.’”

Acknowledging the constraints that faculty, themselves, were under at RUs, students generally bemoaned that the faculty they encountered, regardless, were not sensitive to students’ needs and experiences. For instance, one student expressed, “I feel like they're just here make their money. They don't get how like college kids are starting out on their own.”

Overwhelmingly, a feeling of frustration underscored many students’ perceptions of faculty who they had resorted to labeling “bad teachers,” both regarding practices and commitments to improve their teaching, as illustrated in the following quote:

We need teachers, not professors, that's the kind of class that this is. I don't understand why high school teachers are required to have some sort of education degree but professors just have to have a PhD in their knowledge and that does not make them good teachers. And I have found especially in, like, the physics department and the engineering department. I'm sorry but a lot of the teachers here are incredibly terrible because they don't care about what they're teaching you and they're honestly just really, they take a lot of that frustration out on the students and it's very frustrating to be forced by someone who doesn't want to teach and who doesn't know how to teach. It's just frustrating for everyone.

When sharing stories about the faculty they deemed pedagogical incompetent and uncommitted, students also expressed their frustration with the “weed out” mindset of faculty who teach introductory level classes. For instance, one student expressed that students are very perceptive of a system in lower level STEM undergraduate courses that, essentially, assumes that a fair portion of students should fail or otherwise not progress to the next program course: “You already know that some people are going to be weeded out and they're not going to make it through this class because they're not smart enough to be in the program. I feel like this mentality is also really bad for undergraduates because a lot of the classes are ‘weeding out’ classes.”

Overall, students expressed frustration with the teaching practices and commitments they encountered in their undergraduate STEM education environments. Participants’ perceptions of
these course-based constraints for their learning and engagement were sometimes offered alongside claims of dissatisfaction regarding experiences in STEM programs and, fewer times, across the university level generally speaking. Reflecting on the RU education environment more generally speaking, students reported as constraints to their learning and engagement teaching practices such as “lecturing,” and requirements for their memorization of facts over deeper understanding and “analyzing.”

**Class size and structure.** The large class size at RUs was the second most frequent constraint perceived by participants (n=5) in this study. Most often students associated large size classes with “big lecture halls,” and when recalling their experiences in such environments elaborated on constraints to learning and engagement with “too big,” “overwhelming,” and “can’t keep up with the level of learning.” Participants generally viewed larger classes less favorably than smaller classes because of the limited attention they received from faculty and their inability to assess. Some participants also reported more specific ways in which large classes negatively influenced their ability to learn and stay engaged during class time. For instance, a participant reported that students during large class meetings “can’t focus on the things they are supposed to learn,” and, thus, “don’t even show up to class.” Some students also perceived that their engagement in class did not matter to or would not be noticed by faculty, that they could be absent or “get way with” doing something else (like texting) during class time. For instance, one student said, “I text during class but no one really recognizes that I’m texting because it's too huge and everyone does it too.”

Alongside many student interviewees perceiving large classes as constraints to their learning and engagement, one student mentioned that, because she was part of the honors college, she was afforded “smaller class sizes” and more 1-on-1 time with faculty.” She made this statement with seeming awareness of how large class sizes constrained her friends’ engagement. “I know a lot of my friends and other people that I talk to, their typical class is with 400 other people and it's hard for them to fully benefit from taking those classes when they don't really have any individual attention.” Another participant noted how large classes negatively affected both students and faculty, offering “Having 200 plus people in a class is awful; it really is. The professor will never get the respect that professors deserve, especially from students in the back of the classroom.”

A key solution to the constraints of large class sizes on students’ learning and
engagement was more sections of same course, assuming more personalized instruction that would afford more student learning and engagement. As students noted, “Create more sections of a course with fewer people in them” and “Personalized smaller classes would benefit everyone.” Based on the perspectives participants shared, class size is a factor that can constrain students’ engagement and learning in RU-based undergraduate courses across STEM.

**General education course requirements.** University general education requirements were perceived by three student participants as constraints impacting their learning and engagement in STEM. As illustrated in the following quote, capturing the essence of comments shared by others, courses associated with the general education curriculum were perceived as time consuming and of little to no value.

My biggest problem with the undergraduate program, as a whole in America, is how general all of the education becomes, especially in the first two years. I’m double-majoring in physics and math, and I’ve had to take a bunch of English classes, history, health courses, and at the end of the day, these course are never going to be applicable to my degree. I feel like once we get into college, it's supposed to be a place where we're choosing what we study…The generalization of everything just really creates a lot of problems. Kids lose interest.

These three students perceived their university’s general education requirements as barrier in the way of both graduating on time in their STEM majors, as well as impeding their abilities to focus fully on their STEM majors. Students described their experiences in general education courses using phrases such as “this is busy work”, “this is kind of dumb,” “I am kind of stuck,” “this doesn’t apply to me,” and “I will never use it.” One student’s experience illustrates how required general education courses can be constraints for students’ experiencing curriculum and instruction outside of STEM that would best meet their professional needs and desires:

There are a lot of classes I have to take that I will never use whereas there's ones that I would like to take that I don't have time to take or that don't fit in my schedule because they're not required for biology majors. If I could've subbed out, you know, this class for that class, it would've been a lot more helpful. Cause there's a lot of the classes that are geared towards pre-professionals and not towards researchers. That- so I would like to take more of the research classes whereas people who are pre-professional could take the other classes that I don't really need.
Based on participants’ perceptions, required general education courses are often seen as constraints to learning and engagement in their STEM courses and programs, rather than as affordances for enhancing skills and knowledge for both academic and future professional and personal success, as they are most likely intended.

**Academic advising.** A few participants (n=3) reported perceiving academic support services, particularly related to advising, as constraining their undergraduate learning and engagement in STEM. These participants perceived advising as problematic largely because of the challenges associated with being assigned several advisors and the resulting lack of problem solving that can result, with “I think what's most stressful for me is just the fact that I have a bunch of different advisors. I have my major advisor, and then I went abroad as well so I have a study abroad advisor” and “I've kind of had a merry-go-round of advisers and none of them ever knew who I was which is a problem.” While describing her negative experiences with advising, another student compared advisors to faculty members indicating their large load of students/advisees impeded students getting the attention they need to stay engaged in (and graduate from) a STEM program. “Professors have to teach large lecture halls. You can't expect a professor at a state uni to teach 25 kids at a time. But with an advisor it's actually more important for them to get to know their students because they are supposedly setting you up professionally. But I think I've had 5 total. So this new advisor hasn't even responded to any of my emails, and I'm graduating soon.” Although academic advising was reported as a constraint by only a few students, it is important to highlight because of the key role advising plays in student engagement and persistence in STEM.
Table 2
Perceived Constraints: Ranked-list of Issues Concerning Undergraduate Education at Research Universities Reported by Undergraduates Enrolled in STEM Courses (N=22)

<table>
<thead>
<tr>
<th>Constraint</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty members’ Teaching and Teaching Improvement Practices and Commitments</td>
<td>11</td>
<td>Faculty member’s poor instructional practices and unsupportive attitude, and lack of motivation to improve teaching perceived as constraints influencing student learning and engagement. Students often perceived these constraints as products of unit or institutional culture at RUs</td>
</tr>
<tr>
<td>Class Size</td>
<td>5</td>
<td>Large size classes perceived as a constraint influencing students’ ability to learn and stay engaged during class time</td>
</tr>
<tr>
<td>General Education Course Requirements</td>
<td>5</td>
<td>Amount of time and lack of personal value associated with general education courses perceived as a constraint for student learning in major courses</td>
</tr>
<tr>
<td>Academic Advising</td>
<td>3</td>
<td>Lack of personalized support and guidance from advisors perceived as constraint influencing students’ success</td>
</tr>
</tbody>
</table>

Students’ Perceived Affordances In Undergraduate STEM Education Environments

Six primary categorical patterns emerged as I analyzed the data regarding issues related to students’ perceived affordances regarding their academic success: (a) teaching methods, (b) instructional strategies, (c) students’ cognitive engagement opportunities, (d) additional physical/technological resources (e) instructor personality traits. Table 3 presents a rank-ordered list of the categories and the related perceived affordances, as expressed by at least two of the student participants, which I attend to in greater detail via both text and tables reporting on each of the six categories of students’ perceived affordances.

To begin with, of the 61 student participants, three participants expressed no specific perceived affordances influencing their learning and engagement in STEM courses. These three
students expressed that they had no expectations from their instructors. For instance one student said, “I won’t rely on other people to teach me.” These students described themselves as independent learners with no additional guidance needed from anyone. In addition, an overwhelming majority of students, in fact almost all of the 58 participants, when sharing their perspectives on teaching-related practices, expressed a sense of frustration with instructors whose teaching method mainly comprised of “pure lecturing.” Based on students’ experiences in STEM courses, pure lecturing was most often described as instructors continuously talking throughout the whole class period without using any tools or equipment.

**Teaching methods.** This theme captures the various teaching methods perceived as affordances by 58 student participants for their learning and engagement in STEM courses, specifically small group work/discussions, interactive lectures, lectures using PowerPoint or similar technology, and lectures using chalkboard. Table 3 presents a rank-ordered list of the teaching practices perceived as affordances supported with a description.

**Small group work/discussions.** The most commonly perceived affordance related to teaching methods expressed by students (n=18) involved instructors who included small group work during class time, providing opportunity to engage students with the material together with their peers. Student interviewees citing this affordance often described themselves as “hands-on learners” who preferred to learn by doing activities. Students used phrases such as “hand on fashion of learning” and “mind workout” and “doing physical things” to describe their what such practice afforded. Students claimed that group work “stimulated” their learning and “pushed” them to succeed. The following quote makes this point and captures the essence of comments shared by others:

> I get the most out of group interaction. If I’m participating in the learning process, I feel like I’m getting more material, and I’ve learned the topic or the subject more in depth, when I can discuss and explain it with my peers. If I can get to that level through interacting with other people, I think that’s the pinnacle of the educational goal, my educational goal.

In addition to expressing that group work afforded them opportunities to learn by doing and directly engage with the material, group work was also perceived by students as affording opportunities to learn by interacting with peers. For instance, one student noted that group work offered students’ learning opportunities by teaching the material to their peers: “I think that
group study helps a lot whether you’re the one who doesn’t know much or you’re the one who knows a lot. Just like everyone says when you teach, you learn more. And I think that is true from my experience.”

**Interactive lectures.** Many students (n=14) shared their appreciation for instructors who provided opportunities for interaction during lectures, via techniques such as questions and answers (Q&A) session. One student stated “I really like the idea of the Q&As” and expressed that when instructors offer opportunities to ask questions, students are able to share their problems with the whole class which affords all students to learn from each other experiences: “The fact we have these problems and other students have these same problems too so we can from their experiences.” Students expressed that interactive lectures helped them stay engaged and pay attention to what was being taught by the instructor during class time. For instance one student alluded to this affordance noting that “Just an interactive lecture where instructors are asking questions and making sure everybody is on the same page. I tend to fall asleep in lecture. I really try to pay attention, but if someone is talking to me for like an hour or an hour and a half, I just can’t do it.” Another student said “I just really like, you know someone who can use PowerPoint as a reference, but definitely some sort of interaction helped a lot, especially if you had a two-hour class, you know, or lecture. It’s just so impossible to pay attention.” Another student perceived interactive lectures as affordances for both students and instructors, especially in large classes. He noted that interactive lectures helped students discern whether they are learning the material and instructors to keep track of student attendance: “I think having the interactive components are a good thing mostly because it is such a big lecture so with some lectures you can miss and it will make no difference and nobody will notice that you’re missing.”

The following thoughts shared by one student illustrates how interactive components of a lecture is perceived as an affordance for student engagement, especially large class size STEM courses.

**Lectures with PowerPoint (PPT) slides.** Students (n=12) perceived the use of PowerPoint presentations by instructors while lecturing as affordance that supported their learning in STEM course. However, students were particular about the characteristics of the PPT slides deemed as affordances. In particular, students appreciated instructors who included lots of visual aids such as “pictures”, “graphics”, “examples”, and “definitions” on PPT slides. For instance, one student expressed “I like PowerPoint presentations. If it has like pictures or like terms included and then if he can talk with that, that’s awesome.” Overwhelming, students
reported that PPT presentations helped present and illustrate material in a more organized manner. For instance, one student, while noting the various affordances associated with PPT presentation, expressed how PPT slides helped her keep track of all the information she needed to learn for the course:

I would prefer going to classes and learning it through seeing it on the PowerPoint and her going through it... Like, the equations she had last time, which was helpful. Last time, I had to like, flip through my binder and find that equation. So if everything is presented up there, and described.

In addition, students also clearly expressed the fact that they did not appreciate instructors who just read directly from the slides during the whole class period. For instance, one student reported that he preferred instructors who explained material using the PPT slides as an illustrative tool rather than pack the slides with lots of facts and using these as a recitation prompt: “And I like how he uses PowerPoints that are mostly pictures and not a lot of facts that you have to write down. So he’s illustrating things that he’s explaining in person. And I like that rather than reading the slide and it’s really... I could do that myself.”

Students in general alluded to the fact that PPT slides helped present material in a clear and succinct manner. A quote by one of the student captures the essence of how PPT presentations afforded students an opportunity to better understand the material:

I feel like PowerPoint presentations are really helpful because they’re super clear like you know that the letters are going to be written clearly and people are going to understand it.
I think it would be better to use a piece of paper to elaborate on some things from the PowerPoint, but not write down everything on the PowerPoint.

**Lectures using chalkboard, whiteboard, or overhead projector.** Students (n=8) in this study perceived the instructor’s use of chalkboard/projector while lecturing as an affordance for their learning and engagement in STEM courses. Specifically, students mentioned their preference for instructors who taught the material by actively solving problems, deriving equations, or drawing pictures. The following quote by one student captures the essence of the form of teaching method that involves instructors lecturing, while at the same time hand writing notes/equations using various technologies:

I like it when they write on the board for science classes especially with all the equations that they have and it’s just easier to keep track of in my mind then just a straight
PowerPoint… He’ll talk and then he’ll write something on the board and we’ll do a problem.

One student, in particular, pointed out his preference for instructors who presented material while writing on the board instead of using PPT slides: “I actually prefer my professor who goes through on the board and writes things as we go. So I prefer less PowerPoint, honestly.”

Similarly, another student pointed that even though an instructor provided students with notes with blank spaces that they were expected to fill during class time, she found it helpful when instructors also actively filled out these blanks while displaying the notes on an overhead projector, to ensure that every student is viewing and recording accurate information for their learning:

The teacher created notes with blanks in them, printed them out, everybody got them, and then he would fill that out—essentially do his lecture from those blank notes, filling out the notes on the overhead projector in class while lecturing. It was really helpful because everyone was guaranteed to get the same information.

**Lecture using demonstrations.** Some students (n=5) students also expressed their appreciation for instructors who used demonstrations during lectures to explain a topic or phenomenon. Student perceived the use of demonstrations as an affordance for their engagement, in helping them to stay alert during class time, as well as getting them more attuned to the subject matter. For instance one student expressed: “I think with my most successful courses that I’ve had with big lectures demonstrations are also really key. It helps me get really excited about the topic.” Students perceived demonstrations to be critical part of an active and engaging classroom. The following quote captures students’ appreciation for the use of demonstrations by instructors while also alluding to a stark contrast between a “pure lecture” course and a more active and engaging course:

So I really kind of grew towards all of the professors—the professors who are far more engaging, use lots of demonstrations, and include hands on work. Examples and demonstrations are huge. And I guess that’s kind of what drew me towards this course. Because I’ve had a bunch of negative experiences with very boring, very monotonic, 8:30 in the morning, during which half the class would fall asleep.

**Independent work time.** Students perceived independent work time during class time as an affordance for their learning in STEM courses. For instance, one student found it helpful to
first work independently on problems, during class, prior to the instructor’s elaboration: “I definitely prefer like lecture first, to introduce the material, and then practice problems to follow the material up, and then let students themselves do the problems… like work them out, and then the teachers give the answers and then explain the solution to them.” Similarly another students mentioned that giving students to complete work on their own during class time helped ensure that all students were grasping the material taught during the class period: “For making sure we are all on the same page, she has activities and makes us fill out little handouts and I appreciate it.”

Table 3

*Ranked-List of Teaching Methods Students’ Perceived as Affordances for Their Learning and Engagement in STEM Courses (N=43)*

<table>
<thead>
<tr>
<th>Teaching Methods</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small group work</td>
<td>18</td>
<td>Working together with their peers in small groups to discuss material or to do hands-on activity perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Interactive Lecture</td>
<td>14</td>
<td>Interactive segments during class time involving opportunities to ask questions and share problems perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Lecture using PPT slides</td>
<td>12</td>
<td>Visually appealing PowerPoint slides with lots of pictures, examples, and key terms (but not too many words) perceived as affordance for student learning and engagement</td>
</tr>
</tbody>
</table>
Instructional strategies/techniques. This theme captures the various pedagogical behaviors and techniques that 37 students perceived as affordances for their learning and engagement in STEM courses. The strategies described by students were expressed as general classroom practices of instructor that are not necessarily associated with a particular teaching method. Table 4 presents a rank-ordered list of the instructional strategies perceived as affordances.

<table>
<thead>
<tr>
<th>Instructional Strategy</th>
<th>Rank</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture using chalkboard/whiteboard</td>
<td>8</td>
<td>Instructor’s use of chalkboard/whiteboard/overhead projector to actively to explain material, solve problems, and write notes perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Lecture using demonstrations</td>
<td>5</td>
<td>Instructor using demonstrations to illustrate material perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Independent work time</td>
<td>4</td>
<td>Time to work on problems/activities independently during class time was perceived as affordance for student learning and engagement</td>
</tr>
</tbody>
</table>

**Concept illustration.** Instructors’ use of illustrations to convey and explain material was perceived as affordances by students (n=19), who discussed instructors explaining disciplinary concepts by linking them to students’ experiences, stories, real-life examples, and simulations and movies as affordances for student learning and engagement. Students reported that instructor use of illustrations made learning fun and exciting. For instance one student described a particular instructor’s use of stories to illustrate material and make connection between the content and the real world:

I like geology classes taught in the way I think one faculty does. I’m a sucker for stories. I like it when they piece together little bits of this huge history that is the story of the earth. Something about stories always gets me. There’s something about a story but there’s another thing to feel the story, you know, live it almost.
Another student reported reading examples in an instructor’s notes ahead of class time helped set the stage for better following the progression of a lecture:

I really like the teaching style of the prof’s whose notes are littered with examples. And they tell you kind of what to read ahead of time and you can even read through their notes ahead of time and have a general idea of where this lecture will go.

Students expressed that analogies, specifically, made learning about science theories/concepts engaging and resulted in their better understanding of complicated concepts. For instance, one student shared: “I had a physics teacher who would give us examples like, “Santa Claus is going down a hill in his rocket-powered sleigh and he runs into a gum drop the size of New York.” You know, like, you’ve got to make physics fun like that.”

Students reported how that the use of illustrations was an affordance for general engagement in class, helping them stay attentive. The following experiences shared by one student underscores this influence of the use of illustrations on students:

I would kind like nod in and off but like when I would come back to he was providing like images and videos and examples pertaining to what he was talking about and it interested me because it was things that I have seen in personal experience while I was like snorkeling or while I was at the beach and stuff like that.

**Concept emphasis.** Some students (n=10) perceived the verbal communication of the heightened importance of key information as an affordance, towards their better understanding of material, as well as an affordance in best preparing for exams. For instance, one student expressed that he preferred instructors who communicated the relative importance of certain topics instead of expecting students to read the full chapter:

I’m used to having, for study purposes, set questions and set things I need to know. So my ultimate preference probably for a teaching style would be small groups, with questions asked, but I’ll tell you what you need to know instead of just read the entire chapter.

Similarly, another student noted the value of concept emphasis in the form of study guides, “I love the study guides that the professors give out to us. It just helps us so much in making us understand wait. This is what we need to learn for the test.”

Instructors who emphasize the relative importance of concepts, in the words of one student “specified everything that we need to learn,” affording better understanding and learning of STEM content. Students expressed frustration when discussing their experiences in courses in
which the instructors did not effectively communicate key course information. The classroom environment of these instructors were most often described as lacking structure and organization, and thus were perceived as constraining learning. For example, one student shared his stressful experience in a course in which the instructor did not seem to clearly state both due date and key information they students needed to know: “Professors who seem to do things sometimes less structured makes it really stressful for the student, especially if due dates and key points aren’t stressed by the professor in any clear context.”

**Questioning.** The use of questioning strategies by instructors was perceived by students (n=9) as affordances for their learning and engagement in STEM courses. Students valued instructors who posed thought-provoking questions and encouraged the whole class to consider and pose answers, while at the same time making students feel comfortable in posing questions too. For instance, one student shared his experience in classes in which instructors interacted with students and provided students an opportunity to ask questions, specifically clarification questions, as a way to check student understanding: “I’ve had teachers who are like really good at interacting with the class, like, I’ve got my math teacher this term, and she turns around and says, "Any questions?" People raise their hands when they have questions.” The following thoughts shared by one student, in particular, captures the influence of instructor’s questioning strategies on student engagement: “’Have you experienced this? And if you have, tell me about it.’ I pay a lot more attention. Even like I found myself coming out of sleep and like noticing if he’s asking questions about like something that I am familiar with.’”

**Organization.** Instructors’ good organizational skills were perceived by students (n=8) as affordances for their learning and engagement in STEM courses. Students spoke about their appreciation for instructors who were well-organized, specifically those who described and presented class outlines and material in a structured format. For example, one student mentioned instructor behaviors such as “making announcements at the start,” “tackling material in sections” and “clearly defining term and posting summaries of content taught during class time” when sharing his thoughts about instructors with good organization skills. Another student expressed that an instructor’s organization skills mattered more than an instructor’s teaching methods to students’ success in courses:

I would say organization is key. And, second to that is posting in an organized manner on the Blackboard site, the materials. ‘Cause I’ve had classes before where the instructor
does not provide a lot of visual aids, and that is still OK with my learning style as long as it’s organized. Other professors who seem to do things sometimes less structured, that makes it really stressful for the student, especially if due dates and key points aren’t stressed by the professor in any clear context.

An instructor’s organization skills was almost always linked to how well instructors communicated disciplinary content and transitioned from one topic to another. For instance, one student noted that instructors who are organized verbally communicate the outline of the class and also clearly indicate the content that is to be covered during class, to help students focus and make connections between different topics:

For math and science courses, it’s nice when a teacher can go, “Ok, we’re covering part of this chapter today,” and really like say, what chapter they’re covering, and then say like, “We’re going to be looking at these different equations,” and just explain the equations, and explain like what variables are in them, how to solve for different components, different ways you can arrange them and derive other equations from them, and then, maybe give like one really simple example, so, like, you can follow along with it and say, “Ok, I get this, like I get this, the general concept of it.”

Assessment/Practice with content. Students (n=7) also shared their thoughts on various forms of assessment or practice with content that they either found most or least affording their learning and engagement. Regarding their learning, students perceived assessments that made them “think critically.” For instance, one student expressed her preference for homework assignments that required such thought, as this engagement with the material was more effective than just reading a textbook or slide:

Honestly, I wish there were more homework assignments… I’m taking physics right now and there is just so much homework that I’m forced to spend so much time like thinking and working through stuff whereas like biology I struggle studying because we’re not given like things to work through so it’s like I’ll read the book or look over the slides and there is no critical thinking homework and so I think I do better in classes where there’s more work put on us.

Similarly, another student shared her experience in a course in which she felt disengaged, not only because the instructor mostly talked at a passive class, but also because this instructor did
not assign any homework: “In lectures I find you zone out so easy and you don’t get any real homework, which I’m used to having for study purposes.”

When discussing different forms of assessment, quizzes were described as the greatest affordances for students, exams the least. For instance, one student expressed his preference for quizzes over exams since studying for exams diminished his deeper understanding across this subject areas, in that it took time away from studying for other courses. This student also expressed that the possibility of being quizzed encouraged him to stay engaged with content, to keep up with the reading for his science course:

I love the fact that we don’t have in this class helps me so much with my course load. We have quizzes for which we have to read before class every time because we may or may not have a quiz on it. And that actually helps because it’s like a quick reading that we get to read every day so I take information every day and I stay on top of what we learn in class. And that helps a lot.

**Clickers.** The use of clickers, or technological student response systems, were perceived by students (n=7) as affordances for their learning and engagement in STEM courses. Students noted that clickers, if used effectively by instructors, afforded learning opportunities in addition to encouraging class participation. For instance, one student expressed that clicker questions encouraged him to come to class prepared and ready to contribute to class discussions with his peers to avoid embarrassment, “When it is more interactive with clicker questions and smaller classes then you really have to know the material because you don’t want to look like an idiot in front of the rest of the class.” Students more often claimed other benefits of using clickers, including opportunities to critical thinking and problem solve as well as demonstrate their creativity. For example, one student shared his experience in a course in which an instructor who framed his clicker questions to encourage students to think more critically about the subject matter:

For clicker questions, the professor would put up the graph of what people answered and just be like, “Oh yeah, C and D are pretty good. And oh yeah A is pretty good too.” It’s about being right or wrong in his class, which really has just encouraged my creativity and like encourages me to like speak up and try new things. Every other class it’s just like A or B. This is… oh, it’s B. Like that’s it. Move on. But with him you really have to think.
**Humor.** Instructors’ use of humor was perceived by students (n=4) as an affordance for their engagement. Students appreciated instructors who told jokes or funny anecdotes during class. For instance, one student reported how his instructor’s use of humor helped him stay engaged especially in more technical course where the instructor is explaining equations and solving problems, humor helps him stay engaged, “I do also like the derivation stuff, because, I kind of see, like, where everything is grounded in terms of the equations and stuff. Yeah. Humor is good.” Students in one particular focus group shared their thoughts about their instructor who integrated jokes within homework assignment to entertain students and make the material fun: “The professor writes our homework. Which is funny because you find all these spelling errors and he like hides little jokes and stuff in it.”

**Multimedia.** Instructors’ use of multimedia formats were perceived by students (n=2) as affordances for their learning. One student described himself as a visual learner and therefore preferred learning via the use of multimedia, such as watching a movie, “I’m just so visual like I could watch a movie or documentary and learn so much more than like reading a book about the same subject.” Similarly, another student reported how the use of simulations help students learn more effective by directly engaging with the material:

He uses lots of visuals, he has simulation software that it’s not just a sort of static simulation that you look at and you adjust things on, but he actually can interact with it. You need to be able to go and actually do things, even if it’s a simulation that’s a good approximation. Being able to say, “Oh, I understand why that works now!”

**Movement around the classroom.** Students (n=2) appreciated instructors who walked around the classroom to interact directly with the students, affording students’ engagement. One student mentioned that she prefers when the instructor walks around the classroom while using wireless technology to write notes:

I think it’s really effective that she uses her iPad to write down things. And it really helps the course flow better because she doesn’t have to walk around and then jump onto the computer and click the next slide. She just clicks it from wherever she’s standing and I think it helps her interact with the class better when it’s such a large.

Another student reported that he found it helpful when instructors walked around the classroom while posing questions to students in the classroom:
He walks around a lot, and he asks questions of individual people. And I feel like if you just kind of stay in one place with that class, because I mean, to be once again kind of honest, most of the people in that class talk all the time. There’s like this dull hum of people talking all the way up to the back, and it kills me inside because I really want to pay attention to the material and the professor, but when everyone’s talking it makes it so much harder.

Table 4

*Ranked-List of Instructional Strategies/Techniques Students Perceived as Affordances for Their Learning and Engagement in STEM courses (N = 37)*

<table>
<thead>
<tr>
<th>Instructional Strategies/Techniques</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept Illustration</td>
<td>19</td>
<td>Instructors’ use of examples and colorful visual aids to explain material perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Concept Emphasis</td>
<td>10</td>
<td>Instructors who communicated the importance of key information perceived as affordance for student learning</td>
</tr>
<tr>
<td>Questioning</td>
<td>9</td>
<td>The use of questioning strategies perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Clickers</td>
<td>8</td>
<td>Use of clickers to encourage critically thinking and problem solving perceived as affordance for students’ learning and engagement</td>
</tr>
<tr>
<td>Assessment/Practice with Content:</td>
<td>7</td>
<td>Homework assignments and quizzes over exams perceived as affordance for student learning</td>
</tr>
<tr>
<td>Organization</td>
<td>8</td>
<td>Instructor’s use of jokes and funny anecdotes to explain material and engage students perceived as affordance for student engagement</td>
</tr>
</tbody>
</table>
Students’ cognitive engagement opportunities. Opportunities for students’ mental engagement were perceived as affordances by 29 student participants for their learning and engagement in STEM courses. These types of experiences afforded students’ opportunities to think critically, generate new ideas, and relate the material to the real world. Table 5 presents a rank-ordered list of students’ cognitive engagement opportunities perceived as affordances.

Content connections. Students (n=11) perceived connections to prior material or other subjects made by instructors as affordances for their learning. For instance, one student reported that he valued instructors who discussed how the course material related to other fields. At the same, he also expressed that instructors should also clearly communicate expectations about other subject matter such as mathematics that students needed to learn/know so to better for their exams:

The other thing that I wish too in MECH 2 is that they emphasized the integration of all of the subjects, but I find that they don’t show that enough in our classroom. I wish that the thermodynamics and fluid profs who want to integrate a question on our exam with the math, they should emphasize that and I find that they don’t do that enough.

Similarly, another student stressed how important it is for him to know how the course content relates to other courses as well as the real world:

I felt like there is no information that I’m going to need to reproduce in my future in terms of like a conversation about oceanography or like how it could relate to any other courses. I like to look for that in classes—if one class can overlap with another even if it’s a different subject.

Problem solving. Students (n=10) perceived as affordances for their learning opportunities for problem solving offered by instructors. Students reported problem solving activities as well as those that required applying and constructing new knowledge as affordances for their learning and engagement. One student stated “It’s not just about memorizing and
repeating, it’s about really figuring it out and I really appreciate that [instructor] does that.”

Another student compared solving problems via clickers with just reading a textbook. “In my physics class we did a lot of group work and like figuring out this problem. There would be a weird clicker questions that you’d never seen before. And that I think this is more useful than just going over the textbook again with you.” Similarly another student reported that more open-ended assignments, assigned as homework, encouraged students to take ownership of their learning and make informed decisions:

He gives us goals to reach outside of class. Whether or not you like, or agree with, his decisions, you’re still out there doing that and you can make that decision. He’s very open to letting you make that decision. You know. “Here’s what I want you to do. Decide what you think about it. There’s not a right answer, necessarily, in your response. Just tell me honestly what you think in a brief statement.

Connections to the real world. Instructors who connected material to the real world were perceived as providing affordances for students’ learning and engagement in STEM courses. In particular, students appreciated instructors who also explained how the subject matter is related to various professions. For instance one student said:

I think one of the most important things is that the professor’s able to connect what we’re learning with some real-life applications to something that is important, how it might influence the way in which we pursue our careers, like opportunities.

Similarly, another student mentioned that he was much more interested in the material when instructors illustrated how content related to his persona life:

I would kind like nod in and off but like when I would come back to he was providing like images and videos and examples pertaining to what he was talking about and it interested me because it was things that I have seen in personal experience while I was like snorkeling or while I was at the beach and stuff like that. And so that’s why I was like “Oh, that”— like if it’s something that I’ve seen or experienced, I find more interest in that class because then I’m able to go back through and apply it to what I’ve seen and I feel like I had learned something more from experiencing it.
Table 5
*Ranked-List of Cognitive Engagement Opportunities Students Perceived as Affordances for Their Learning and Engagement in STEM courses (N =29)*

<table>
<thead>
<tr>
<th>Cognitive Engagement Opportunities</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Connections</td>
<td>11</td>
<td>Instructor who made connections between different subjects perceived as affordance for student learning</td>
</tr>
<tr>
<td>Problem Solving Experiences</td>
<td>11</td>
<td>Instructor who gives students' opportunities to apply material to actively solve problems perceived as affordance for student learning</td>
</tr>
<tr>
<td>Connections to Real World</td>
<td>10</td>
<td>Instructor who relates material to students’ everyday lives and professions perceived as affordance for student learning and engagement</td>
</tr>
</tbody>
</table>

**Additional physical resources/technology.** Of the 61 student participants, 22 reported other affordances for their learning as other physical resources/technology, including notes provided by the instructor, course textbook, or other reading material as helpful tools for their learning. Table 6 presents the rank-ordered list of perceived affordances related to use of additional resources and technology.

**Notes.** Students (n=13) appreciated instructors who provided notes on the material to be discussed in class ahead of time. Some students specifically expressed that writing their own personal notes on the notes provided helps them stay engaged during class. However, a few students mentioned that they are able pay better attention to what the instructor is saying when the notes are already provided prior to class and they didn’t have to actively take any additional notes during class. A few students mentioned that filling out the “notes with blanks” helped them stay focused during class time. For instance one student said,
But I really like how [instructor] posts everything online ahead of time. We can go through and look at the slides. And he leaves blanks for us to fill in during class time. I don’t actually use that. I think most students do use that. But it’s really helpful to go back and kind of be able to take my notes that I’ve taken and fill in those blanks later. It’s kind of an extra little bit of studying that you know, helps me kind of go through the information again.

In contrast, some students reported although they preferred receiving the notes ahead, they particularly preferred a “complete set of notes” and not “incomplete notes.” Receiving an incomplete set of notes via the instructor prior to class, for these students, defeated the purpose of notes and they felt like they spent more time take more notes instead of paying attention to the instructor.

That’s what I appreciate the most is that she gives us the complete set of notes so that we don’t have to write down the basic ideas because to me in the STEM classes that’s the most aggravating part is when people purposely give me incomplete notes so that I’ll quote unquote take notes.

Course website. Students (n=5) reported that they appreciated instructors who used online services such as Blackboard to post course materials including grades. Students expressed that having access to course materials was an affordance to their meaningful studying and helping them to stay organized. For instance one student said expressed:, “I really enjoy when professors put the things that they went over in class on Blackboard because it allows the students to return to it and feel organized and structured in their at-home study time.” Another student mentioned that an instructor’s video tapes of her lecture afforded student engagement and learning in class:

She posts the lectures. It’s super nice that she posts her podcasts. They go online. They’re videotaped. The whole lecture. It’s like the screen so you can see her writing and stuff. I don’t have to take notes in class and I like that because it hurts my hand to do that sometimes.

Textbook. Students (n=5) spoke about the affordances of instructor-textbook alignment, in terms of outline and presentation of content. Students expressed that being able to follow the format of the material the way it is presented in the textbook were affordances to their learning. Another student mentioned that she appreciated instructors who strictly followed the outline of the textbook because it helped her stay organized and pay better attention in class:
I really, really, really appreciate when they go directly from the book. Like when they follow the book really well because I personally am a really slow learner, and it’s difficult for me to take notes and listen at the same time. I really need that resource to go back and kind of re-go over the material. If they just work from the book, it always turns out really well for me.

**Alternate reading material.** Students (n=2) discussed optional readings, assigned by instructors, as affordances to their learning. One student said she preferred reading articles rather than reading a “dry boring textbook.” Another students mentioned that he appreciated instructor who posted articles on content that would help students learn more about the subject matter that personally interested them.

I like how, with those quiz folders and the readings, it’s kind of like a free learning sort of environment in which, okay, these are things I highly recommend that you learn. Otherwise, it could affect your grade. In addition, if you’re really interested in this, follow these links and you can learn more. You won’t be tested on it. It’s just out there.

Table 6

**Ranked-List of Perceived Affordances Related to Use of Additional Resources and Technology Reported by Students as Supportive of Their Learning and Engagement in STEM courses**

(N =22)

<table>
<thead>
<tr>
<th>Physical Resources/Technology</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes</td>
<td>13</td>
<td>The provision of notes was perceived as affordances for student learning and engagement</td>
</tr>
<tr>
<td>Website</td>
<td>5</td>
<td>Instructors who posts relevant resources such as notes and reading material posted on class board (e.g., Blackboard) was perceived as an affordance for student learning and engagement</td>
</tr>
</tbody>
</table>
Instructors who outlines courses based on the content of the textbook was perceived as an affordance for student learning and engagement.

Instructors who offers interesting alternative readings other than the textbook was perceived as an affordance for student learning and engagement.

### Instructor’s traits.

Of 61 student participants, 14 expressed the critical role of instructor’s personality traits as affordances towards their learning and engagement in STEM courses. Table 7 presents the ranked-list of perceived affordances related to instructors’ personality traits.

**Enthusiasm/Passion.** Instructors’ passion about the subject matter was perceived by students (n=8) as an affordance for their learning and engagement. Students noted that instructors who were enthusiastic made courses more engaging and exciting for students. Students also expressed their appreciation for instructors who related content to their personal daily lives. For instance one student expressed that when instructors apply what they teach in their everyday helps builds better instructor-students connections:

I really like how he recalls his past experience and is a good advocate, like a really hard core advocate, on what he’s teaching. So, he’s like leading by example and not just by talking about it. It really helps me connect with him more. He’ll show us slides about how he does sustainable things at his house or works for non-profit organizations.

Another student noted instructors who are passionate about the subject matter motivated students to learn:

And I also like to say it’s great to have a teacher who’s passionate about the topic. It can be infectious and motivate students to study material and work together and discuss inside and outside the class.

**Approachability.** Instructors’ approachability was perceived by students (n=7) as an affordance for student learning and engagement. During conversations related to instructor’s personality, students expressed that they highly valued who did not seem intimidating and
provided a relaxed learning environment for students. The following quote captures the influence of an instructor’s supportive attitude on student learning:

Some of my instructors don’t just lecture but also help outside of class. They don’t make you feel stupid for not knowing how to do something while others might just make it intimidating to seek help when you need it. Some instructors are good at not making you feel intimidated to seek help outside of class.

Students felt more comfortable asking questions and expressing concerns when they felt that their instructors took the opportunity to get to know their students at a more personal level. One student shared his experiences in a course where the instructor knew each student’s name and was willing to build personal connections with students:

[Instructor] is really good about actually knowing our names and really interacting with us. He really knows everybody I think by their first names. And I think that that makes a huge difference. Having an understanding of who he is and just connecting with us. So my preference is that either the classroom has to be small or the teacher has to be really dedicated to being friendly and being accessible.

Another student noted that an instructors’ approachability was sometimes intricately linked to teaching style, affording student engagement via a supportive environment:

I think a lot of it has to do with how engaged, how interested the professor him- or herself is. That’s really evident to me, in someone’s teaching style, if they really care about it, then they will have examples, and they will have applications they can talk about, and they will have answers to questions and analogies. But if they don’t care about the class, they’re just there to teach, and they’ll write down equations and that kind of thing.
Table 7

Ranked-List of Perceived Affordances Related to Instructors’ Personality Traits Reported by Students as Supportive of their Learning and Engagement in STEM courses (N = 14)

<table>
<thead>
<tr>
<th>Instructor’s traits</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enthusiasm/Passion</td>
<td>8</td>
<td>Instructors’ interest in subject matter perceived as affordance for learning and engagement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instructor who is approachable and friendly perceived as affordance for student learning and engagement</td>
</tr>
<tr>
<td>Approachability</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Discussion, Implications, and Potential for Future Research Directions

Reiterating A Push to Consider Students’ Perspectives on Teaching Practices

To help administrators, policymakers, and researchers understand why so many students still abandon STEM majors and what might help more of them persist, in this study, I set out to understand students’ perspectives on the educational practices at research universities (RUs), specifically to examine the factors students’ perceived as affordances and constraints for their learning and persistence in STEM. The results that emerged indicate that poor instructional practices continue to be perceived as one of the major constraints, for student learning and engagement in STEM courses, similarly to findings offered two decades ago (Seymour & Hewitt, 1997) demonstrating that poor teaching as the most significant factor in more than 60% of students nationwide abandoning undergraduate STEM majors. Per my findings of students’ perceptions, poor college STEM teaching practices at RUs may still be partially to blame for the relatively low number of students completing an undergraduate degree in the STEM fields. Although Seymour and Hewitt’s groundbreaking study spurred many national efforts to improve teaching in STEM courses and to retain more students in STEM fields, the status of
undergraduate STEM teaching continues to remain a pressing concern (PCAST, 2012; National Research Council, 2012).

Postsecondary educators, leaders, and policymakers must do more to address the STEM education crisis and better support the success of undergraduate students. However, to enhance and sustain the impact of improvement efforts, it is essential to understand and address the concerns students have with the education environment at research universities, particularly in STEM disciplines. I adopt the stance of others that recognize students as the ultimate experts of their own experiences and argue that we must stop overlooking unique and authentic perspectives on higher education in conversations and planning to improve postsecondary STEM education (Cook-Sather, 2012; Torchia, 2011). As argued in an earlier section, if the ultimate desired outcome of undergraduate STEM improvement initiatives is to foster student learning and engagement, then change agents including researchers and faculty must recognize and consider perspectives of students who are ultimately the end recipients of any potential changes/transformations. According to Noah Finkelstein, a prominent advocate of undergraduate STEM education reform, “distributed expertise is needed to stimulate improved undergraduate instruction. Successful programs bring together students, faculty, administrators and often community members in creating sustained programs” (Committee on Science and Technology, 2011, p.8).

Specifically, students’ perceptions of teaching-related practices and factors are paramount, as US postsecondary institutions try to respond for faculty to make a shift towards creating and offering student-centered learning environments in STEM courses. If education is to be truly student-centered, then student perspectives on their educational experiences including their perceptions of the learning environment should not only be considered but should be the main driving force for all decision-making and strategic planning concerning education and its improvement (Cook-Sather, 2002). Grounded in this notion, students in this study were given an opportunity to openly express, through direct conversation, their perspectives on educational practices.

**Students’ Perceived Constraints Regarding Their Learning and Engagement, and Some Potential Alleviations**

STEM faculty who do not value teaching and who were not interested in making the efforts to teach more effectively were perceived as a very salient constraint to student learning
and engagement in STEM courses. Comments from students regarding the poor quality of teaching they encountered in STEM courses were also tied to students’ perceptions of an unfavorable academic culture at RUs that glorifies research productivity over teaching. In fact, students perceived this unfavorable culture as the main constraint for why faculty lack the motivation to change their practices, followed by the less prevalent perception that faculty “just don’t care.” Another interesting finding that emerged from students’ perspectives was their awareness of how the unfavorable culture negatively affected even instructors who they perceived to be good teachers. Student were aware of the fact that instructors primarily responsible for teaching, who were often interested in improving their teaching, are negatively perceived by others in the department for caring about their teaching.

The perceptions of my student interviewees advocate for continued improvement initiatives that are targeting transforming of the culture in which STEM faculty work, to one in which teaching and research are equally valued and recognized (Anderson et al., 2011; Association of American Universities, 2011; Weiman et al., 2009). The focus on transforming academic culture holds great potential for change since, theoretically speaking, both faculty members’ and students’ actions related to their success are influenced by how they perceive and make meaning of the affordances offered by their environment (Gibson, 1979). I contend that when STEM disciplines foster a culture in which teaching and research are equally valued and recognized, affords both faculty members and students opportunities to achieve their desired outcome. Faculty will more likely be interesting in putting in efforts to teach (more) effectively, As a result of faculty implementing more effective teaching practices, the affordances available in the classroom environment that better support students’ success in STEM will more likely be enhanced.

Students often discussed certain teaching practices as impeding their learning and engagement. An overwhelming majority of student interviewees shared a perception that equated to despising a “pure lecturing” practice, during which instructors talk continuously while students passively receive information. There is evidence, both anecdotal (Weiman et al., 2009) and empirical (Hora & Ferrare, 2014; Hora, 2014), that this more typical type of lecture remains a dominant way undergraduate students are taught in STEM courses (Handelsman et al., 2009; Watkin & Mazur, 2013; National Research Council, 2012). Based on this finding, and related
affordances shared by student interviewees, I advocate for more diverse practice repertoires on the part of STEM faculty (discussed in greater detail below).

In addition to the teaching practice of “pure lecture,” participants also perceived the time-consuming general education required courses as a constraint towards their academic success, particularly towards their learning in major-related courses. Students expressed that time spent studying for general education courses could have been better spent learning the material in their major courses that that were pursuing based on their interest and future career. To address this concern, it is important for educators and university administrators to ensure and clearly communicate the purpose and value of general courses, for students’ academic success and also success in their professional and personal lives.

Interactions with academic advisor were also perceived as a constraint by some students regarding their learning and engagement. These students’ perceived advisors as not making an effort to build personal connections with students, and otherwise not effectively supporting or guiding them in making academic-related decisions. There student perceptions call to attention the important role of academic advisors in undergraduate student success, especially at RUs. Academic advising is one of the only structured activities on college campus in which all students have the opportunity to interact personally with a college staff member and receive guidance and counsel on issues concerning their college experiences and future career options (Kuh, Kinzie, Schuh, & Whit, 2011). RUs should make it a priority to support the professional development of both academic advisors and other key personnel who can mentor students in STEM disciplines.

Students’ Perceived Affordances Related to Teaching Practices in STEM Courses

Collectively, comments from my student research participants, regarding perceived affordances related to teaching practices in STEM courses, were relatively complex descriptions of teaching. This finding stands somewhat in contrast to research on teaching practices that have often been studied using simplified dimensional classifications and ratings and ambiguous and overly subjective explanations (Hora & Ferrare, 2013; 2014). Partially attributable to my methodology, of course, students shared their perceptions of a plethora of affordances that influenced their learning and engagement in STEM courses. In addition to teaching methods,
students’ perceived affordances related to *instructional strategies*, *cognitive engagement opportunities*, *physical/technological resources*, and *instructor’s personal traits*. Of note, my study concerning students’ perspectives regarding what best secures their learning and engagement demonstrates a large diversity of affordances. As well, affordances for their learning and engagement were typically not discussed by students in isolation with one another. An overwhelming majority of students appreciated instructors who “break up” class time via a diversity of teaching-related practices and factors. For instance, some students preferred instructors who lectured with PowerPoint to explain important equations, stopping occasionally to deliver an illustration to connect complicated equations to “real life”, and turning frequently to writing on boards to show them how to enact equations to solve problems. Some students preferred instructors who first more traditionally “lectured” to introduce new material and then provided active learning opportunities for students to cognitively engage with the material and with their peers. The following quote highlights the diversity in teaching practices that afforded one student’s learning:

> He stops in between every PowerPoint slide and he’ll visually draw stuff on the board, and he’ll stand there and ask more engaging questions or provide scenarios to further each slide. So it’s… the slide is there for you to reference back, but then he also breaks it down on the board to where you have to take notes as well. So he finds a medium between the two that you actually do have to—you can’t completely zone off.

Indeed, per my findings, students’ notion of affordances that best support their learning and engagement in STEM indicates that students’ conception of teaching is as a complex and multi-dimensional phenomenon. The question of what is the most effective teaching practice for students is not simple. The representation of teaching-related practices and factors, as emerged collectively from students’ perspectives, affirms Hora and Ferrare’s (2014) notion that teaching is a complex activity and, for an in-depth understanding, teaching needs to be operationalized as a multi-dimensional phenomenon in which various teaching-related components interact with one another over time, both within and outside the classroom. As such, when describing and assessing quality of teaching in STEM classrooms, one needs to resist the temptation to seek simplistic and single dimensional classification, ratings, descriptions, and explanations. Figure 1 illustrates the multi-dimensional of teaching that emerged from students’ perspectives of teaching-related practices and factors that act as affordances for their learning and engagement in
undergraduate STEM courses.

Figure 1. A multi-dimensional and complex view of teaching, that emerged from students’ perspectives of teaching-related practices and factors that act as affordances for their learning and engagement in undergraduate STEM courses.

At the broadest level, this model represents the teaching and learning context within which students can experience certain dimensions of affordances that help them learn and engage in STEM courses. The first dimension includes the various teaching methods that the instructor implements in the classroom such as small group work and interactive lectures. The second dimension includes the pedagogical strategies and techniques used by instructors in the classroom, such as the use of illustrations and questioning strategies. The third dimension represents the various critical thinking opportunities provided for students in the classroom, such as the opportunity to problem-solve or create new knowledge. The fourth dimension represents the resources that support student learning, such as the provision of notes. Finally, the fifth dimension involves the instructor’s personality, specifically their level of approachability and enthusiasm for the subject matter.

These dimensions should not be seen as discrete affordances or features of pedagogy, but
rather as interconnected complex interactions. Students’ comments clearly indicated that they can and do perceive teaching as a multifaceted phenomenon that involves more than the just instructors’ teaching method. Students discussed teaching based on the totality of their experiences in college classrooms that attended to the very meaningful affordances of very specific education instructional technologies and instructors’ personality traits.

The data reported in this paper also illuminates diversity across student perspectives on the types of teaching-related practices and factors that help them learn and engage in STEM. Many of these student perspectives support what educational research and theory already claims as best college teaching practices. Teaching practices such as group problem-solving, interactive lectures, use of clickers for formative feedback, and concept illustrations to better help unpack difficult concepts for students fall under the umbrella of student-centered instruction known to better support student learning and engagement. While students are unlikely to be familiar with education research and theories, their lived experiences—and their sensemaking and sharing of this experience—reflects much of what the larger education community already recognizes as affordances for their learning and engagement, in STEM and beyond. As such, I hope my study serves as an impetus for other researchers and faculty to recognize students among those who have the knowledge to inform educational practice and shape education reform.

**Implication for Faculty Teaching Practices**

Per my data, I offer a suggestion for STEM faculty based on salient teaching-related practices and factors that emerged as affordances for students’ learning and engagement in undergraduate STEM education. Despite the growing national debate about lecturing in classrooms, students in our study indicated that they appreciated instructors who used a variety of teaching practices, and that included lecturing as well as active learning techniques. Therefore, instead of “taking a hard line” in “choosing sides” in the debate on lecturing versus active learning (a similar caution offered by Hora, 2014), I urge faculty to focus on diversifying their teaching practices to help all students learn and engage in STEM. However, this does not mean that exclusive traditional lecturing is still appropriate. Instructors should pay careful attention to how a lecture is delivered and organized to convey and explain material. Based on students’ perspectives, lectures can be meaningful for learning and engagement when supported by appropriate tools and techniques such as well illustrated Powerpoint slides and questioning
strategies to get students involved in the learning process. Good instruction involves more than just more “traditional” lecturing; it also includes the use of appropriate strategies and techniques to create a learning environment that engages students to critically think and apply knowledge to solve real and complex problems. It is important to note that any teaching practice implemented at any given time during the class period should be used in a meaningful and thoughtful way to promote student learning and engagement.

My recommendation for instructors to use diverse teaching and learning approaches, instead of adopting of one teaching method over others, is supported by the work of other researchers. As with others cited in my literature review above, Walker and his colleagues (2008), in their quasi-experimental study focused on examining the effects of active learning on student learning outcomes and evaluations of course and instructors, found that students showed a strong preference for a balanced mixture of active learning opportunities and lecture-mode class formats. Based on student narratives obtained via focus groups, students valued a class structure that equally included both active-learning exercises and mini-lectures. In the book *What the Best College Teachers Do*, Bain (2010) included the following quotes by an outstanding professor: “The brain loves diversity” (p.116) and “I don’t think there’s much evidence that most people have exclusive learning styles and can’t learn in any way but one, but I do think that we all benefit from variety” (p. 177). My recommendation to instructors affirms others’ recommendation that instructors adopt diverse teaching practices systematically integrated within each class period; specifically my data points to the need to include lecture practices interspersed with critical thinking opportunities. By integrating diverse forms of teaching practices and approaches, instructors may be able to maximize the strengths of each affordances associated with classroom practices to students’ learning and engagement.

In addition, I contend that students’ perspectives should not only be considered in the evaluation of teaching they have already experienced, but also directly put to use in the designing of instruction and classroom environment. Based on my data, students seem somewhat surprisingly able to identify and communicate specific teaching-related practices and factors that serve as affordances for their learning and engagement. Taking into account these student perspectives, via direct conversations at the point of planning curriculum, instruction, and other teaching-related activities and deliverables may go a long way in helping to better meet students’ needs. The college student and business leaders quoted below emphasize how easily students are
ignored, and how important it is to rectify this ignorance (cited in Bovill, 2011):

I think some teachers... are so focused on getting stuff done that they don’t pay attention to their students, who I think are the most valuable resources in a classroom. (Mihans, Long & Felten, 2005, p. 9)

Asking students to talk about their education is so simple that—whether we are teachers, parents, researchers, or policymakers—we inevitably forget to do it. (White, 2010, p. xi)

**Implications for Practices Concerning Student Perceptions Data**

This study has several implications for the work of researchers and faculty desiring to improve undergraduate STEM education via student-provided feedback data. While many key stakeholders may still be hesitant to include students’ perspectives in conversations and decision-making processes related to educational practice (a hesitancy I hope to have alleviated via arguments throughout this paper), there are many, in fact, who have purposely attempted to respond to student perceptions data in their efforts. The notion of asking students to provide feedback on the quality of teaching that they experience has been a common practice since the mid-1920s in the American higher education system (Abrami, d’Apollonia, & Cohen, 1990; Marsh & Roche, 1993). At college and universities, semesters typically end with students filling out course evaluations. To date, student evaluations of teaching (SETs) have been the most common method for receiving feedback on teaching quality, largely because they are convenient and time-efficient (Stark & Freishtat, 2014) and connote a “standard” in eliciting student feedback at an institution. However, at a time when the calls to improve of education via data driven decision-making have been increasing at the postsecondary level (Bouwma-Gearhart & Collins, 2015), criticisms on the part of faculty regarding SETs are extra salient. SETs have been a source of both satisfaction and frustration among faculty and researchers, and mostly the latter; a recent study conducted by the American Association of University Professors found that thousands of professors question the efficacy and credibility of course evaluations (Faherty, 2015). Several researchers have recently reported that SETs fail to adequately describe teaching quality, and they have called on higher education leaders and faculty to use other means to elicit students’ perceptions about teaching-related practices and factors (e.g., Weiman, 2015; Stark & Freishtat, 2014).

While skepticism surrounding the mandated use of SETs is warranted, I argue that this skepticism should not translate into downplaying the meaningfulness of student perspectives in
informing teaching-related practices and factors and planning for their improvements. Rather, this skepticism should focus on the form of the evaluation itself. SETs, in mostly questionnaire formats, do not provide opportunities for students to openly express, in their own words, their perceptions about teaching-related practices and factors. I urge those who may question the credibility of students’ perspectives solely based on the use of SETs to not disregard students from critical conversations on teaching and education reform. I highly recommend researchers and faculty see students as valuable resources and give them additional opportunity to better share their perspectives, via data-collection processes and tools that can reflect just how rich and nuanced their perspectives are.

**Limitations and Future Research Directions**

My study is limited in the following ways. While the small sample that this study draws on allowed for a more personalized and in-depth look into students’ perspectives, I cannot claim that students’ perspectives presented in this paper are representative views. They are a selection from those enrolled in STEM courses at three research universities, and therefore I do not suggest that these are typical, or that all undergraduate across the United States would share these perspectives. It is rare for research studies to give students an opportunity to describe in their own words their perspectives on their classroom experience or, in fact, their overall experiences in higher education. Therefore, although the findings of this study may limit the scope of generalizability to the entire undergraduate population of the three selected universities or any other institutions, I encourage higher education researchers, especially those committed to improving undergraduate education, to recognize the “added value” in having direct conversations with students Future researchers could build upon this study by examining whether constraints regarding undergraduate education that emerged from discussions with student remains consistent with a larger sample of undergraduates. It is also important to point out that the research question that elicited students’ perspective on undergraduate education was biased towards problems/negative. Therefore, future research is warranted. To create the conditions of the educational environment that positively influence student academic success, it is important examine both affordances and constraints perceived by students.

Given that this study focused primarily on students from STEM courses, future research could focus on capturing students’ perspectives on teaching-related practices and factors deemed affordances in non-STEM disciplines, to determine similarities and differences between their
preferences for and expectations of teaching in STEM and non-STEM courses. Furthermore, given my conclusion, and the insistence of other researchers, that teaching is multidimensional, I urge researchers to move away from using reductionist approaches to study and evaluate teaching, including students’ perceptions of teaching. Like many other researchers, such as Hora (2013; 2015) and Ebert-May (2011), I advocate for researchers to adopt the use of research tools and techniques that capture the complexities of teaching in more robust and descriptive manners.

As I have already argued for throughout this paper, I highly recommend the inclusion of students’ perspectives captured via more descriptive methods such as focus groups and interviews.

However, I also recommend the use of in-classroom observations using descriptive protocols such as the Teaching Dimensions Observational Protocol (TDOP) to capture a more complete picture of teaching including the various dimensions of teaching indicated by students in our study (Hora, Ferrare & Oleson, 2013; Hora & Ferrare, 2014). The TDOP is a structured classroom observation protocol that takes into account the multidimensional and complex nature of teaching allowing for both more descriptive and rich descriptions of teaching, as well as quantitative accounting of such. Future research could modify such an instrument to better capture the teaching-related practices and factors deemed affordances by students in my study, to ascertain which, and in which combinations, are most present, and which are most absent, in STEM classrooms.

Additionally, I contend that it is time to conduct another national-scale study as a follow-up to the groundbreaking work done by Seymour and Hewitt (1997), to examine whether the reasons for why students continue to abandon STEM majors identified almost two decades ago are still relevant. While additional research is needed to develop our current understanding on the attainment disparities in STEM, it is also important to investigate the reasons for why students who continue to persist in STEM majors, despite all the barriers students perceive/experience in STEM disciplines. Identifying these key affordances may help educators leverage on practices and assets that many contribute to success in STEM. As STEM education continues to be a national policy priority for the US, a large-scale study focused on understanding students’ perspectives on undergraduate education at research universities and particularly in STEM disciplines is warranted to increase the momentum to transform undergraduate STEM education.
and to retain more students in STEM fields, especially student from underrepresented minority groups.
CHAPTER III

Examining STEM Faculty Members’ Motivations to Engage in Teaching Professional Development: Implications for Improvement in Postsecondary STEM Education

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Introduction

The Status of Undergraduate STEM Education in the US

In recent years, the STEM education crisis in the United States has been increasingly amplified in public discourse, research journals, national policy reports, and even the mainstream media. The major problem contributing to the US STEM education crisis is that many students, particularly underrepresented minorities abandon STEM majors early in their academic careers (Chen, 2013). A recent report by the Higher Education Research Institute (HERI) (Degree of Success: Bachelor’s Degree Completion Rates among Initial STEM Majors, 2010) revealed that not only are first-year STEM majors more likely to switch fields of study before they graduate, but they are also more likely to drop out of college than their non-STEM counterparts. The high attrition rates of students from STEM fields are particularly alarming given the current US economic climate (National Research Council, 2012). The President’s Council of Advisors on Science and Technology (2012) reported that the United States needs an additional one million STEM graduates in the coming decade to meet STEM workforce demands and to remain economically successful and globally competitive. At the same time, there are compelling arguments for an enhanced need for the nation’s citizenry, writ large, to possess more STEM literacy, basic understanding of STEM knowledge and skills needed to think critically and make well-informed decisions on socio-scientific issues (e.g., global warming) of increasing societal importance (Singer, Nielsen, & Schweingruber, 2012; Weiman, 2007).

Formal postsecondary education holds potential for helping to address such concerns. Yet a 1997 study revealed that an overwhelming 90% of students abandoning STEM majors cited poor teaching as one of their primary concerns about undergraduate STEM education (Seymour & Hewitt, 1997). Seventeen years later, undeniably, poor quality of teaching in STEM disciplines is still, at least in part, to blame for students not just leaving STEM majors, but dropping out of college entirely (National Research Council, 2012). However, there is growing momentum to remedy the poor status of STEM education, particularly teaching, in STEM disciplines. Fortunately, many government officials, education policy makers, researchers, university administrators, and faculty have united in recent years around a common goal of change, to make undergraduate STEM education more appealing to and effective for a larger percentage of the population (Association of American Universities, 2011). Towards more effective, postsecondary educational experiences for all, there has been enhanced focus on
STEM classrooms and educators’ teaching practices (Anderson et al., 2011; Association of American Universities, 2011; Weiman et al., 2009).

**Transforming the STEM Classroom and Educator Practices: The Impetus and Calls**

Indeed, the improvement of teaching in undergraduate STEM classrooms is central to the concerted effort of transforming STEM education (Association of American Universities, 2011; Weiman, 2007). This follows per significant body of research, within the past few decades, that has shown that more “traditional” methods of teaching (such as faculty lecturing with limited active engagement on the part of most students) fails to foster the scientific understanding, critical thinking skills, and reasoning that are required for the 21st century workforce and citizenry; yet there is evidence, both anecdotal (Weiman et al., 2009) and empirical (Hora & Ferrare, 2013; 2014) that this more typical type of lecture remains a dominant way undergraduate students are taught in STEM courses (Handelsman, et al., 2007; Mazur, 2013; National Research Council, 2012). While Matthew Hora (2014) has made a compelling argument that “the jury is still out” on lecturing’s efficacy of practice writ large, the prevalence of traditional lecturing in STEM undergraduate courses has been identified as a major contribution to attrition in STEM over the last quarter of a century (Brainard, 2007; Fairweather, 2008; Seymour & Hewitt, 1997; Weiman et al., 2009).

But what should replace these more traditional and effective methods? A significant amount of research and scholarship in STEM education calls for a fundamental shift in pedagogical practices, from “teacher-centered” to more “student-centered” (Fairweather, 2008; Henderson, Beach, Finkelstein. 2011; Labov, Singer, George, Schweingruber, Hilton, 2009). *Student-centered instructional practices*, if implemented effectively, are characterized by active learning techniques that that engage students in the learning process, unlike traditional lecture practices during which students are passive recipients of information (Chi & Wylie, 2014; Felder & Brent, 1996; Machemer & Crawford, 2007; Powell, 2003; Prince, 2004). *Active learning* “requires students to do meaningful learning activities and think about what they are doing” (Prince, 2004, pg. 223). These active learning techniques do not diminish the need for lectures; instead, they follow the constructivist view that meaningful learning occurs when students are actively engaged with disciplinary content through tools such as discussion, hands-on activities, and problem solving (Felder & Brent, 1996; Fink, 2003; Paulson & Faust, 2008). Examples of student-centered active learning practices include, to name a few, those that fall under the
genera term active learning (Freeman et al., 2014), as well as interactive engagement (Tlhoaele, Hofman, Naidoo, & Winnips, 2014), and peer-led instruction (Mazur, 1997). A growing body of research shows that student-centered instructional strategies in STEM education, grounded in theory of how people learn, are more effective in improving conceptual understanding, knowledge retention, and attitudes about learning than traditional lecture-based methods that do not involve student participation (Bransford, Brown, & Cocking, 1999; Chi & Wylie, 2014; Freeman et al., 2014; Prince, 2006; Handelsman, et. al., 2004). Despite several decades of education research documenting these effective pedagogical strategies, and their success in STEM, there is significant evidence that such practices have not yet become the norm in undergraduate STEM education, especially at the institutional type of focus for my dissertation, that being research universities4 (Association of American Universities, 2013; Baldwin, 2009). While Brainard (2007) points out that “no one can say with much precision” how many faculty members are utilizing such practices (p. 2), recent research and frameworks are, in fact, attempting to quantify, or at least better estimate, the prevalence of teaching practices across postsecondary STEM (for example, see Hora & Ferrare’s 2014 research using their Teaching Dimensions Observation Protocol).

The reasons for the reform lag at research universities (RUs) are complex and multifaceted, yet one of the most widely cited significant barriers is the unfavorable culture at RUs, towards the efforts to improve undergraduate STEM education (Anderson et al., 2011; Baldwin, 2009;). While university leaders talk about the importance of transforming teaching practices at their institutions, academic departments value and recognize research output and abilities over teaching effectiveness when considering STEM faculty5 for promotion and/or tenure (Fairweather, 2008; Savkar & Lokere, 2010; Weiman et al., 2009). STEM departments

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4 I define research universities per the Carnegie Foundation’s 2014 Institutes of Higher Education classification, to include those universities labeled as large four-year research institutions with majority undergraduate enrollment, and very high/high research activity. See http://carnegieclassifications.iu.edu/lookup_listings/institution.php for additional elaboration.

5 I use the term faculty to refer to those that teach at research universities and that potentially qualify for promotions, both those on the “tenure-track” and those not. Yet, it is important to note that most research concerning unfavorable “climate” at research universities regarding teaching and improvements to teaching mostly pertains to the impact of such climate on tenure-track faculty, who need to demonstrate strengths as disciplinary researchers for promotion.
fear that an emphasis on teaching will make them less competitive in the race for prestige, in which the winners are determined by their research accomplishments (Brainard, 2007).

Regardless of the reasons for the slow and sporadic rate of change in STEM disciplines, the support for STEM education transformation continues to be strong. Notable sources of funding for academic research—from federal agencies such as the National Science Foundation (NSF) to private foundations such as the Howard Hughes Medical Institute (HHMI)—extended their support in the early 21st century to strengthen the quality of teaching and learning in the STEM disciplines (Baldwin, 2009). In addition, disciplinary societies that influence some norms for faculty members’ professional work (e.g., the Accreditation Board for Engineering and Technology, the American Chemical Society, the American Physics Society) have also promoted an urgent need to improve undergraduate STEM education (Baldwin, 2009). Postsecondary STEM education improvement initiatives are largely collectively focused on enabling this culture change in which universities more broadly recognize, value, and reward teaching so that faculty are encouraged to equally commit to their teaching and research missions (Association of American Universities, 2011; Anderson et al., 2011; Baldwin, 2009).

Acknowledging Faculty Agency and an Emphasis On Their Pedagogical Professional Development

Notwithstanding the various factors that complicate students’ chances to successfully complete postsecondary STEM degrees, no doubt the pedagogical practices of faculty ultimately have a significant impact on shaping the future of undergraduates’ trajectories, and our nation’s workforce and populace (American Association of Universities, 2011; National Research Council, 2007; PCAST, 2012). Yet, even in the face of this seemingly obvious reality, most STEM faculty begin their teaching careers with little or no professional training in pedagogy and little or no knowledge about the evidence supporting the link between effective teaching practices and student engagement and success (Austin, 2004; Gardiner, 2000; The Boyer Commission Report on Educating Undergraduates in the Research University, 1998). Research on educators’ development and practices, K-20, indicates that this reality is incredibly problematic. Faculty ultimately make most decisions related to curriculum and instruction, at both level of program and, even more so, at the level of learning environment, such as classroom or laboratory; these decisions are based on their own expectations and past experiences,
department and institutional climate, and other local professional pressures (Bouwma-Gearhart, 2012; Hora, 2013). At the key site of the classroom or laboratory, individual faculty are most often the only ones positioned to make decisions about what should be taught, how it should be taught, when it should be taught, how it should be assessed, and what any assessment data should inform (if anything).

Unfortunately, the teaching practices of most faculty members (both new and experienced) are informed by flawed models of teaching practice that they themselves experienced prior to their entry into the profession (Harper & Hakel, 2008). Typical experiences leave faculty assuming that teaching primarily involves transfer of information and that learning is the simply the acquisition of information with fidelity as to how it was presented. Such perceptions, widely distributed among STEM faculty at RUs, might be called cultural models of teaching and learning, and ultimately impact faculty members’ pedagogical practices (Ferrare & Hora, 2014). Though many factors influence faculty teaching decisions and practices, such as availability of teaching-related tools and artifacts, the cultural models that many STEM faculty continue to hold is one main reason for the widespread use of the traditional lecture in STEM classrooms and the lack of adoption of evidence-based instructional practices (Ferrare & Hora, 2014). Simply put, if faculty members continue conceptualizing teaching and learning within standing cultural models, significant improvements to STEM education are unlikely to happen.

Individuals hold cultural models as mental constructs and many education researchers have emphasized that a significant shift in educators’ mindsets (i.e., beliefs and attitudes) is a must for successful and sustained instructional change in postsecondary STEM (Connolly & Millar, 2006; Henderson & Dancy, 2007). One means towards shifting mindsets, what others would call mental models or schemas (Ferrare & Hora, 2014), is participation in professional development activities and programs that are intended to develop in STEM faculty greater expertise regarding research-based teaching practices (Austin, 2002; Fairweather, 2008; Bouwma-Gearhart, 2012). According to Thomas Guskey (2002), an education expert well known for his work in educator pedagogical professional development and education reform, “notable improvements in education almost never take place in the absence of professional development” (p. 4). According to Stephen Huber (2011), both formal and informal forms of professional development, plays an essential role in the “professionalization” of teachers as professionals, and enables a successful transfer from theory to practice, and from knowing to acting. (p.837-838). In
the context of higher education, professional development offers opportunities for faculty to learn certain skills or gain knowledge related to issues associated with change efforts, to practice new teaching methods grounded in learning theories, and to receive guidance from others (Kezar, 2009). At a time when improving undergraduate STEM education is an urgent national need, emphasis on teaching-focused professional development (TPD) for faculty is vital to facilitate positive instructional change, writ large, and promote the effective use of research-based effective educational practices, specifically.

Acknowledging the significance of TPD in changing teaching practices, many individual institutions, disciplinary societies, and professional organizations have sponsored the implementation of various TPD activities for STEM faculty across college and universities. These TPD activities are typically informed by research on teaching and learning, and are diverse in timeframe and scope (Bouwma-Gearhart, 2012). These activities that support faculty professional development occur not only on one’s own local campus but also in large-scale national programs, and are somewhat diverse in delivery. In her inquiry into the TPD experiences of STEM faculty at RUs, Bouwma-Gearhart (2012) found that STEM faculty participated in and found certain TPD forms most meaningful (reported descending order of appeal): “(1) workshops, seminars, or courses; (2) consultation of teaching resource material, paper or electronic; (3) colleague to colleague mentoring; (4) consultations with individual education centers or with education “experts”; and (5) grants/sabbaticals for work on teaching curriculum/instruction (p.182). In recent years, TPD activities have also included faculty obtaining regular and timely feedback from experts via classroom observations on their teaching behaviors (Ebert-May et. al., 2011; Hora & Ferrare, 2014). And various disciplinary societies and RU-focused improvement consortiums have offered TPD workshops, or series of workshops, targeting STEM faculty. These include: a one-day workshop for chemistry faculty, The Process Oriented Guided Inquiry Learning (POGIL), sponsored by the American Chemical Society; a three-day workshop in engineering, National Effective Teaching Institute (NETI), offered by the American Society for Engineering Education (ASEE), a week-long Summer Institute workshop in biology, sponsored by the National Academies and the Howard Hughes Medical Institute (HHMI); and long-term professional development and mentoring provided by the Center for the Integration of Research, Teaching, and Learning Network (CIRTL). All of these TPD workshops share common objectives, namely to increase STEM faculty members’
awareness and adoption of evidence-based instructional practices and commitments to curricular and instructional improvements. Underlying these objectives is the ultimate, and ambitious, goal of enhancing student learning and advancement in postsecondary STEM education, and attracting more qualified students to STEM careers.

A Close Look at Faculty Teaching-Focused Professional Development (TPD) Experiences: Participation, Motivation, Barriers and Competencies

Yet research points to many barriers in the way of RU STEM faculty members’ work to improve their teaching practice. The most commonly cited barrier for instructional change identified in the literature is lack of time (Brownell & Tanner, 2012; Henderson & Dancy, 2007). Faculty most often are too busy juggling with demanding teaching and research responsibilities (Brownell & Tanner, 2012; Henderson & Dancy, 2007). The second most common cited barrier reported by faculty is insufficient training. Many faculty do not feel prepared to make changes in their instruction (Brownell & Tanner, 2012). Finally, in recent years, the most often cited barrier for widespread change in STEM faculty teaching practices is the academic culture in STEM disciplines that emphasizes research over teaching. Thus, incentives such as lower teaching loads, financial benefits, recognition for tenure, or even just verbal acknowledgment from colleagues and supervisors, to spur change is often lacking in STEM disciplines (Anderson et al., 2007; Brownell & Tanner, 2012; Henderson et al., 2010; Weiman et al., 2009). Interestingly, what encourages STEM faculty to participate in TPD is largely unexplored (Bouwma-Gearhart, 2012).

The literature on TPD for faculty has continued to increase during the past few years, getting its start in the 1970s (Gaff & Simpson, 1994). In recent years, much of the work on TPD, particularly in STEM disciplines, has been focused on examining the strategic planning and structural components of TPD activities, as well as on the effectiveness of the TPD activities (Bouwma-Gearhart, 2011; Connolly & Millar, 2006). In particular, research into the effectiveness of TPD that offer STEM faculty opportunities to learn about active, student-centered instruction has begun to focus on whether what faculty learned via their participation is implemented in their classrooms. As the ultimate goal of improving the quality of undergraduate STEM instruction is to increase student engagement and learning, researchers are continuing to
attempt to find effective and convenient ways to measure the impact of TPD workshops on student learning outcomes (Ebert-May et al., 2011; Graham et. al. 2013; Pfund et al., 2009).

While the actual implications of faculty members’ participation in TPD is somewhat unknown, there is little doubt that faculty participation in TPD can accelerate change efforts targeting undergraduate educators’ practice (PCAST, 2012).

However, evidence regarding actual participation of STEM faculty at RUs in the US in TPD is largely anecdotal. Most do not participate in TPD in spite of awareness of TPD offerings. Although, few would disagree with this assumption, research to examine whether this actually holds true among STEM faculty is warranted. Improvement initiatives and TPD developers and implementers could benefit from knowledge concerning who participates in TPD (and who does not), when they participate in TPD, and how much they participate in TPD. Thus, this study examines trends in participation in TPD among STEM tenure-track faculty at RUs. Additionally, despite knowing something about its efficacy in changing and sustaining faculty beliefs and instructional practices (Connolly & Miller, 2006), a significant shortcoming in recent TPD-focused research is the lack of emphasis placed on examining what motivates faculty to participate in such activities (Bouwma-Gearhart, 2012). Indeed, examining what motivates faculty to participate in professional development is equally important, especially if there is aspiration to increase participation, as well as new TPD strategies to maximize the impact.

Guskey (2002) has noted that the majority of TPD programs aimed at educators K12 fail and are deemed ineffective because they do not take into account two crucial factors: (a) the processes by which change in educators typically occurs, and (b) what motivates educators to engage in professional development in the first place. Furthermore, Guskey (2002) argues that for successful outcomes, TPD must be seen as a process, not just an event. This conceptualization of TPD further justifies the importance of understanding what gets faculty to professional development in the first place.

Thus, my study also explores faculty motivation to participation in to TPD. My in-depth look into motivation participation in TPD will be informed by a well-recognized theory of human motivation (described below). What gets faculty to participate in TPD will help determine factors that could serve as leverage points to not only ensure continued participation but also those faculty members who typically avoid participating in teaching-focused professional development.
Furthermore, framing professional development as a process rather than an event begs to examine what happens after faculty members participate in TPD. Huber (2011) asserted that examining changes of the characteristics of participants, such as individual’s competencies to modify their practice, and modified performance of the participant is central to evaluating the impact of professional development on an individual’s learning, “cognitive learning success and increase in knowledge”, and behavior, “the modified performance of the participant” (p.844-845). Although to accomplish change in a faculty members’ learning and instructional behavior teaching via their engagement in TPD can take time and can sometime be difficult, knowledge on immediate and long-term impacts of TPD is necessary not only to identify skills and knowledge gained via TPD participation but also to examine the change (if any) in feelings of competence for their work as a result of their participation (Guskey, 2002; Huber, 2011).

*Competence*, a construct related to self-efficacy, is an individual’s desire to control and master the outcome (Deci & Ryan, 2002).

Competence with respect to an activity is important because it fosters individual's goal attainment and also provides them with a sense of need satisfaction from engaging in an activity at which they feel effective (Deci & Ryan, 2002). In particular, research has shown that high levels of competence in teaching is strongly associated with successful future performance, increased enthusiasm, increase commitment to learning about various pedagogical methods (Connolly, Lee, Hill, & Associates 2015; Neimeic & Ryan, 2009). I argue that TPD programs provide opportunities for faculty to increase their competence in teaching and ability to implement effective teaching practices. Therefore, along with motivations to engage in professional development, my study also addresses the impact of PD by specifically examining the relationship between faculty participation in TPD and teaching competence. Faculty at RUs are most often professionally identified as researchers and not as teachers (Brownell & Tanner, 2012), therefore in his study, I compared their competence to teaching and research, and correlations between TPD and teaching and research competencies.

**Paper Foci**

Specifically, I argue that since faculty work at RUs predominantly concerns research and teaching, it is important to examine their perceived competence for these two responsibilities. Faculty motivation to engage in TPD has been shown to be regulated by their needs and
surrounding educational environment (see Bouwma-Gearhart, 2012, as discussed more fully below), yet this research is so far woefully limited. It is important to closely explore with more faculty members motivations to engage in TPD, towards identifying effective strategy to improve the quality of undergraduate STEM education. I contend that a better understanding on how competent RU STEM faculty feel to teach and do research will help faculty themselves address their professional needs to maintain and nurture both their research and teaching identities within the context of their work environment. Knowledge concerning the teaching and research competencies will also help research institutions and TPD agents to place the appropriate supportive conditions that satisfy faculty needs and address barriers to change.

This paper reports on research into TPD experiences of RU STEM faculty, specifically by examining their motivations to participate in TPD, including affordances and perceived barriers to their participation, and perceived competence for teaching associated with their participation in TPD. Specifically, I define teaching-related professional development (TPD) as programs and activities that engage faculty members in reflection or learning about the practice of teaching with the intent to improve one’s or others’ teaching knowledge or practice. Overall my results revealed that most STEM faculty in our sample participated in TPD and many via multiple TPD experiences/activities. In fact, their participation in TPD was mostly regulated by autonomous reasons compared to controlled reasons. However, controlled reasons significantly reduced with subsequent participation and were least impactful for full professors. The most common barriers reported by STEM faculty was concerning lack of time and unfavorable institutional/departmental culture. Lastly, my results indicate that all faculty, regardless of academic title or participation in TPD, had a higher level of competence for teaching compared to their competence for research. However, investigation also revealed those who participated in TPD felt more competent to teach compared to those who did not participate in TPD and that full professors felt more competent to teach compared to associate and assistance professors. Based on my results, I recommend those promoting STEM faculty teaching improvement, and participation in TPD specifically, not assume that research faculty do not care about teaching and typically avoid participation in TPD and be cognizant that RU STEM faculty may be motivated to participate in TPD for both external and internal factors. My findings indicate that leveraging external factors, such as offering rewards or time release, could potentially encourage faculty members’ earliest participation in TPD, especially for earlier career faculty. Lastly, policymakers
and funders should continue support for TPD program as well as strategies such as the use of rewards and incentives to encourage TPD participation should be leveraged because TPD is associated with numerous benefits including increased competence for teaching.

**Theoretical Frameworks**

**Realms and Factors Influencing Faculty Behavior Work**

As Bess (1997) has noted, three realms specifically influence faculty behavior: the self, the local organization, and the wider system of higher education. To this I add the larger macro-level of cultural contexts that implicate many more factors of influence locally and beyond, including disciplinary and larger societal factors. As is the case with all human motivation concerning work, faculty motivation can be correlated with phenomena originating from the various realms independently but also influenced by the complicated interplay of the various realms. Research, specifically on promoting instructional change efforts, suggests that faculty function within a sociocultural context, and therefore success of any educational innovation is influenced by how faculty respond to various features and norms of the sociocultural and organizational context in which they embedded (Lattuca & Stark, 2009).

My research is based on a number of other theoretical perspectives. Below I summarize these perspectives and highlight how they impact our study design, data analysis, and interpretation of results.

**Affordance Theory.** As faculty work is influenced by the departmental and institutional context within which they are situated, it is important to examine how faculty perceptions of the environment influences their envisioned participation in TPD (Hora, 2011; Lattuca & Stark, 2009). My research concerning STEM faculty participation in TPD is rooted in Gibson’s notion of organismic reality. Gibson posits that an individual’s actions (including learning and engagement) cannot be studied in isolation from the individual’s environment (Gibson, 1979). In fact, the “world,” as conceptualized by Gibson, consists only of those things perceived by individuals in its environment (Gibson, 1979). Central to Gibson’s (1979) view of the world is the concept of *affordance*, or the opportunities for individuals’ actions based on their perceptions of the environment. According to Gibson (1979), “the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill” (p. 127). Gibson’s concept of affordances is rooted in a sensory perception of the natural world (hence the term ecological
psychology). Gibson’s affordances is best illustrated by Sadler and Given’s (2007) description of how a rock is perceived by a reptile and a human:

A reptile in a desert might perceive a large rock as a place to sunbathe or a place to hide; a human might perceive the same rock as a weapon or a building material. There is no “correct” use for the rock, only the affordances perceived by various perceivers (p. 117).

This relationship between organisms and the environment lies at the heart of the concept of affordance (Sadler & Given, 2007). However, a noted deficiency of affordance theory is a lack of attention to how an organism makes sense of an affordance. I thus also rely on the theory of sensemaking which stipulates that organisms (including humans) situate perceptions of affordances in preexisting mental constructs (schemas) that have been themselves constructed via their experiences with other environmental affordances (Letiche & Lissack, 2009).

Applied to the context of my study, the affordances of the faculty members’ environment within which they work (norms, policies, priorities, etc) are what the faculty can perceive as potentially supportive or delirious for their envisioned participation in TPD. I report grounded findings on affordances that faculty perceive as barrier to their engagement in in TPD classroom, including their perceptions of themselves, and other resources within the education environment that support their needs related to teaching. In contrast to affordance, which I default to describe factors described by faculty as having a positive impact, I use the term constraint to identify any quality of the educational environment that restricts faculty to perform an action, i.e. learning and engagement. In this analysis, I consider the perceived constraints as well as the perceived affordances of education environments in STEM disciplines, which taken together may spur TPD participation.

**Human Motivation**

The various realms and factors influencing faculty behavior may impact motivation. It is typical for modern theories of motivation to address how sources impacting motivation may intersect, and it is this interplay that may serve as a more accurate depiction with respect to most humans’ realities. Many modern motivational theories are of the cognitivist as well as socio-cultural veins, and assume that human cognition in response to environmental stimuli, what I have conceptualized as affordances, including social and cultural affordances, best explains most human behavior; in fact, a wide array of rigorous research confirms this assumption. For purposes of this study, I use one of many well-tested theories of motivation, self-determination
theory (SDT), as a theoretical framework, alongside affordance theory, to explore STEM RU faculty participation and motivation to engage in TPD.

Self-determination Theory. Self-determination theory (SDT) is based on the premise that humans naturally coordinate their actions to foster their growth towards satisfying three basic psychological needs: competence, relatedness, and autonomy (Deci & Ryan, 1985, 2002). Competence, or self-efficacy, is the felt belief of an individual that she/he has the ability to influence certain outcomes. Relatedness is the felt experience of an individual in having satisfying and supportive social relationships. Autonomy is an individual’s felt sense of choice, or, perceived locus of causality (Deci & Ryan, 1985).

Based on the extent to which the social environment supports or constrains the satisfaction of the three basic psychological needs, human beings can either be regulated by autonomous or controlled motives to engage in a task (Deci & Ryan, 1985). Simply stated, SDT differentiates motivation in terms of autonomous and controlled regulation. A Regulation involves an individual’s felt sense of choice and acting with a sense of volition or willingness (Deci & Ryan, 2000). An individual who obeys a rule solely for fear of punishment that would otherwise result, is exhibiting the most extreme form of controlled regulation, in which one feels no, or very little, autonomy to participate in the activity. On the other “side” of the motivation spectrum is autonomous regulation. There are two general bases for autonomous regulation: intrinsic motivation and well-internalized extrinsic motivation. Individuals are intrinsically motivated when they find the activity or goal inherent interesting and enjoyable, largely attributable to the nature of the activity. For example, a faculty member may be motivated to participate in teaching-focused professional development activities because they inherently interested in improving their practice to better support the learning of their students. Well-internalized extrinsic motivation is considered to be a more autonomous, or self-determined, form of motivation, via processes known as identification and internalization. These forms of extrinsic motivation involve personal endorsement of activities or goals, not to inherent enjoyment with respect to them, but because of their emergent value to an individual (Deci & Ryan, 2000). For example, individuals who perceive activities or goals that are competitive in nature may be extrinsically motivated but still autonomously regulated as they have identified and/or internalized the value of such activities leading to the attainment of a long-term plan, such as gaining promotion at a job. Because both intrinsic and identified/internalized forms of external
regulations involve choice and volition, they are often combined under the conceptual umbrella of *autonomous motivation* (e.g., Vansteenkiste et al. 2004).

In contrast to autonomous regulation, *controlled regulation* involves feeling externally pressured to perform a task (Deci & Ryan 2000). In particular, controlled regulation can be categorized into *external* and *introjected regulation*. Individuals are considered to be externally regulated when they engage in an activity to meet external demands, avoid punishment, or obtain a reward (Deci & Ryan 2000). For instance, some faculty might be focused on improving their teaching compared to others because they were promised rewards for being among the top teachers in their departments. Individuals can also pressure themselves to participate in an activity by pushing their engagement in an activity because of feelings of shame and guilt for poor performance, and promises of self-fulfillment and pride for good performance. For example, some faculty may feel bad about themselves when they do not out perform their peers in teaching, and they may feel a sense of self-importance when they do better than others. Their engagement in activities to improve teaching is thus regulated by *introjected forces*, emanating within themselves but nonetheless are experienced as stressful and pressuring. Because external regulation and introjection are governed by externally or internally imposed pressures, they are often conceptualized under the umbrella of *controlled motivation* (Deci & Ryan, 2000). Self-determination theorists sometimes discuss motivation at a level of discrete regulations (e.g., intrinsic motivation), whereas at other times, scholars take a broader perspective, examining the overall degree to which individuals feel self-endorsement and ownership versus pressure over their behavior. I utilize both approaches in this study. Figure 2 displays motivations discussed within self-determination theory as well as their position in an autonomy continuum.

![Figure 1](image)

*Figure 1.* Forms of motivation differentiated within self-determination theory and their position in an autonomy continuum.
SDT applied to education contexts. Since Ryan and Connell’s (1989) first examination of elementary school students’ autonomous versus controlled reasons for studying, dozens of studies have applied SDT’s conceptualization of human motivation within the educational domain (e.g., Black & Deci, 2000; Niemeic & Ryan, 2009). However, most of the research concerning application of SDT in education is focused on understanding students’ experiences, their motivation to engage in specific activities and to learn, more broadly speaking. In the context of improving the quality of undergraduate STEM education, understanding of students’ experiences, such as motivations to engage classroom-related activities and their specific psychological needs and relationships with faculty, is obviously very significant. However, understanding STEM faculty experiences, such as their competence for teaching and motivation to improve their teaching, is equally important to effectively realize change in undergraduate STEM education.

This study is part of larger mixed methods study focused on systematically and empirically investigating STEM faculty members’ motivations to engage in teaching-related professional development (TPD). The qualitative phase of the study explored the phenomenon of faculty motivation to engage in TPD with twelve STEM faculty members employed at a large public research university in United States. In the qualitative phase of study, my research advisor, Dr. Jana Bouwma-Gearhart, found that faculty experiences with and motivations concerning TPD resonated with SDT as a theory of motivation. Specifically, findings supported SDT’s prediction of the correlation between three inherent needs of autonomy, relatedness, and competence, and RU STEM faculty motivation to engage in TPD. With respect to their earliest TPD participation, RU STEM faculty sought connections with others like them about teaching in protected environment (relatedness) and strived to better their teaching practice (competence). In relation to feelings of competence with respect to research, participants indicated relatively low felt competence regarding their teaching and desired to remedy this. Stated another way, feeling especially good at other aspects of their work (research) led them to want to bring other aspects of their work (their teaching) in better concordance with their otherwise strong sense of professional self.

Feelings of low competency with respect to teaching, for Bouwma-Gearhart’s twelve subjects, were due to others’ (their students and colleagues) feedback that indicated that they were relatively poor educators. In seeking to increase their teaching efficacy in relation to issues
that SDT would qualify as largely involving their *ego*, largely in response to external pressures, the 12 faculty participants in this first phase demonstrated, at least initially, controlled regulation to participate in TPD. Specifically they seemed to exhibit what SDT terms *introjected regulation* in relation to their earliest TPD participation. None reported they were autonomously motivated to participate in TPD initially. Bouwma-Gearhart (2012) found that these 12 participants were, in fact, mostly “converts” to the cause of TPD. As a consequence of their engagement, they found that TPD addressed aspects of their teaching practice that they had not initially recognized needed attention, further strengthening in their minds the *importance* of TPD. With continuous TPD participation, faculty motivation to continue to participate in TPD became more autonomous (Bouwma-Gearhart, 2012). This phase laid the groundwork for the purpose and research questions of the quantitative phase of the study

**Study Focus and Research Questions**

The purpose of the current study, described in this paper, was to examine RU STEM faculty members’ TPD experiences, including motivation to engage in TPD and their perceived level of competence potentially influencing and resulting from their TPD participation, with a larger array of STEM faculty members (than Bouwma-Gearhart’s original study), with diverse academic tenure-track titles (assistant, associate, or full professor). Specifically, I wanted to see if experiences of a small sample in Bouwma-Gearhart’s qualitative study bore resemblance with a larger and more diverse faculty population. Additionally, I wanted to explore faculty motivation to engage in TPD in light of various factors potentially not discovered in Bouwma-Gearhart’s earlier work. Specifically, I wanted to explore faculty members’ motivation for both earlier, versus subsequent, TPD participation, as well as relative competence for teaching and researching. I also desired to use confirmed quantitative tools pertaining to relevant SDT constructs. With respect to these foci, I also desired to know if there may be significant differences based academic title (i.e. point in career), specifically assistant, associate, or full professors. Lastly, I desired to test the strength of SDT, including its underlying constructs, in accounting for the experiences of a greater number of STEM faculty from public RUs. My quantitative study was guided by the following questions:

1. What are the general trends in RU STEM tenure-track faculty participation in teaching-focused professional development (TPD)?
2. What motivates faculty to engage in TPD? What are the positive affordances?
3. What are the barriers to faculty participation in TPD? What are the negative affordances?
4. How does faculty motivation for initial participation in TPD compare to subsequent (or more recent) participation in TPD?
5. How does faculty competence in teaching compare to their competence in conducting research and how is this related to TPD participation?
6. Do the experiences implicated in questions 1-5 differ across official points in career, by assistant-, associate-, or full-professor designations?

My rationale for the focus on public RUs is primarily based on two reasons. Although public RUs represent only 10 percent of all US 4-year colleges and universities, they enroll a large percentage of students including students from underrepresented minority groups (Katkin, 2003). In 2009, US public research universities enrolled 33% of first time, full time undergraduate students (National Science Board, 2012). Furthermore, according to a report by the Association for Public and Land-Grant Universities (APLU), among the one million minority students enrolled at RUs, 80% attend public RUs (McPherson, Gobstein, & Shulenburger, 2010). In addition, public RUs are known to train the majority of the future faculty members, specifically in STEM disciplines (Austin, 2002; Gaff & Lambert, 1996). Reform efforts focused on improving STEM education particularly at RUs needs continued attention since RUs largely set the norms for how to teach science and what it means to learn science (Wieman, Perkins, & Gilbert, 2010). Finally, public RUs are widely recognized as a national asset in the area of education making significant impacts on educational practice at all levels including K-12 (National Science Board, 2012).

The focus on tenure-track faculty in STEM disciplines is primarily driven by the national attention on improving on the teaching practices of these faculty members (Anderson et al., 2011). The general perception is that tenure-track faculty particularly in STEM disciplines are typically excellent researchers but bad teachers, and are the most resistant to change the way they teach (Brownell and Tanner, 2012). Despite several calls for reform, hundreds of education research publication on effective teaching practices, and substantial amounts of funding to stimulate change, there is little evidence that tenure-track faculty are reconsidering their approach to teaching (Henderson et al., 2011; Tagg, 2012). Therefore, this current study was designed to better understand pedagogical change in higher education by specifically examining
tenure-track faculty STEM faculty members’ TPD experiences and motivations, and exploration of related factors and phenomena.

**Methodology**

**Researcher’s Ontological and Epistemological Assumptions**

Based on the primary aim of this study, my ontological stance acknowledges the multiple realities of faculty that are shaped by their personal conceptions, and the departmental and institutional context within which they work. Thus, my epistemological stance is anchored in the pragmatic constructivist approach in exploring the generation of knowledge, understanding, and meaning around phenomena; my research methodology acknowledges these human interactions in shaping realities (Guba & Lincoln, 1994). As stated above, I make some assumptions about my research participants’ ability to make sense of their realities, shaped by their perceptions of affordances situated within their environment. Consequently, a qualitative and quantitative methodological approach was best suited for this research. These perspectives resonate with my own beliefs about the world, the construction of knowledge, the value of subjectivity in research as well as my own commitments to improving education, including commitment to involve key stakeholders (student and faculty) in visioning and enacting education improvement activities. As stated above, I also make some assumptions about my research participants’ ability to make sense of their realities that are shaped by their perceptions of affordances situated within their environment.

**Background and Research Setting**

While the larger study employs a two-phase exploratory and sequential mixed-methods design, data for the quantitative phase of the study (the subject of this paper) was collected via a mostly quantitative survey. In 2010, my research team (myself, my advisor, Dr. Bouwma-Gearhart, and colleague Dr. Stephen Schmid) selected three large, public RUs located in the southeastern region of the United States. We selected these study locations because of their similarities in the size of their undergraduate populations, research activity, external grants and funding, and accreditation requirements in STEM disciplines; all were classified as RUs with very high research activity (RU/VH) (Carnegie Foundation for the Advancement of Teaching, 2014).
Participants

Email invitations to complete the online survey were sent to all identifiable STEM faculty at the three selected RUs in the US. A total of 289 individuals from various STEM disciplines responded to the survey, equating to a conservative estimate of a 13% response rate. For the purposes of this study, faculty who did not complete the entire survey were excluded from the analyses, as were faculty who held positions such as instructors, postdoctoral fellows, and emeritus professor. Hence, all analyses were based on a final sample of 227 tenure-track STEM faculty members from the three public RUs.

The sample consisted of 161 (71%) males, 63 (28%) females, and 3 (1%) who chose not to specify one of these two forced categories. The vast majority (95.2%) of the participants had a PhD in their respective field; the rest reported their highest degree acquired as either Doctor of Pharmacy (PharmD) or Doctor of Medicine (MD). Using National Science Foundation (NSF) designations regarding STEM fields, our sample was heavily comprised of faculty who were associated with life/biological sciences (n=77, 34%), agricultural sciences (n=43, 19%), and engineering (n=37, 16%), with the rest indicating they worked in the fields of chemistry (n=7, 3%), physics (n=12, 5%), computer science (n=10, 4%), pharmacy (n=8, 4%), geosciences (n=7, 3%), mathematics (n=6, 3%), and “other” related fields not acknowledged by NSF, such as kinesiology and behavioral sciences (n=13, 6%). With respect to point in career/academic title, 64 (28%) were assistant professors, 66 (30%) were associate professors, and 96 (42%) were full professors. Most of the STEM faculty in the sample (n=161, 71%) were tenured, and 57 (86%) were non-tenured, but on the tenure track. Of these, 37 (65%) would potentially achieve tenure within three years. For detailed information about the study sample see Table 1.

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6 We sent out 2270 emails to those who seemed to hold faculty or instructor positions in a STEM department, as defined by the National Science Foundation (see https://www.lassp.org/help/help_stem_cip_2010.cfm for these designations). We cannot be sure how many of these emails failed to reach their intended recipient or how many reached recipients who were not, in fact, STEM faculty or instructors. Thus, a valid calculation of response rate is not attainable.
Table 1

*Description of STEM Faculty Sample*

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<th>Percentage</th>
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Environmental Science   7   3
Geosciences           7   3
Mathematics             6   3
Other                   13   6

Procedures

Survey Development. The online survey was co-created with my co-investigators, Dr. Jana Bouwma-Gearhart and Dr. Stephen Schmid, based on the qualitative phase findings and pertinent parameters from self-determination theory. Two well-established SDT questionnaires were modified and included to assess perceived competence with respect to respondents’ teaching and research practices, as well as the reasons for participating in TPD. The complete survey consisted of Likert scale and open-ended items within Survey Monkey, a web-based survey development software program. Based on the purpose and research questions that guided the study, the format of the survey was organized to assess: (a) faculty motivation to engage in TPD, including motivation for initial and more recent participation in TPD activities; (b) the strength of SDT as an explanatory theory, including its underlying constructs, in accounting for the experiences of a greater number of STEM faculty from RUs, (c) factors that served as affordances (both positive and negative) for faculty participation in TPD, and (d) perceived competence for research and teaching, specifically in relation to participation in TPD. Thus, items were developed that could explicitly test findings from the qualitative phase, as well as other factors potentially impacting motivation to engage in TPD. See Appendix F for a copy of the final survey.

Survey Pilot. A pilot of this initial survey was conducted at the same research institution as the qualitative phase of the study with 91 STEM faculty. Based on feedback from faculty, we made minor revisions to our survey, mostly concerning organization and structure of the sections in the survey.

Survey Analysis. I conducted all the data analysis needed to address the research questions that guided this research study. In particular, I organized and managed the data for this study, and used SPSS quantitative analysis software to conduct all the required statistical analysis.
Survey Constructs, Example Items, and Construct Analysis. The faculty survey included the following constructs, with related example items and analysis:

Trends in STEM faculty participation in (TPD) sub-survey. This sub-survey consisted of many questions meant to assess more basic information about past TPD participation. This sub-survey was based on the qualitative phase findings (Bouwma-Gearhart, 2012) Examples of questions examined in this study included:

1. Have you ever participated in teaching professional development?
2. At what point during your academic career did you participate in teaching professional development?
3. Have you participated in more than one teaching professional development activity?
4. How many times have you participated in teaching professional development?

Motivations for STEM faculty engagement in TPD sub-survey. A modified version of the Learning Self-Regulation Questionnaire (SRQ-L) developed by Ryan and Connell (1989) was used to measure participants’ motivational responses to why they participated in teaching professional development. Ryan and Connell (1989) used self-determination theory to develop a Self-Regulation Questionnaire (SRQ) that included three questions about why people engage in a particular behavior. The following are the three questions that ask participants for the reasons why they engage in teaching professional development:

1. “I will participate in teaching professional development…”
2. “I am likely to follow other’ suggestions regarding my teaching…”
3. “The reason I will continue to broaden my teaching skills is…”

The SRQ was developed using a simplex-like pattern (Guttman, 1954) so the questionnaire was formed with just two subscales: controlled regulation and autonomous regulation. Thus, the 14 Likert-scale type (1 = Not true at all; 7 = Very true) responses grouped under the three questions are either controlled (i.e., external or introjected regulation) or autonomous regulation (identified regulation or intrinsic motivation). Specifically, seven of these responses are controlled (e.g., “because I would get an award of some kind”) and the other seven reasons are autonomous (e.g., “because learning to teach well is an important part of being a professor”). The subscale scores for controlled and autonomous regulation were calculated by averaging the responses on the seven items on each subscale, respectively. A summary score called the Relative Autonomy Index (RAI) was calculated as measure of each respondent’s
overall extent of autonomous regulation for participation in TPD, by subtracting the controlled subscale score from the autonomous subscale score.

Barriers to envisioned participation in TPD sub-survey. This section of the survey included 15 Likert-scale type statements that asked respondents to rate the extent to which various situational and personal factors served as potential barriers to their participation in TPD. These barrier-related questions were generated based on barriers influencing TPD participation expressed by faculty during the qualitative phase. Respondents rated each statement among the following levels of agreement: strongly disagree = 1, disagree = 2, agree = 3, and strongly agree = 4. Examples of these statements include:

1. “I think the training will not help me in my teaching.”
2. “Development as a teacher is not an activity my department supports with respect to tenure prospect.”
3. “I do not have time.”

Motivations for initial versus subsequent participation in TPD sub-survey. This sub-survey consisted of items that asked those respondents who had participated in at least two TPD activities to compare the extent to which their reasons for initial and recent participation in TPD were autonomous and controlled. This questionnaire was developed based on the various reasons for engaging in teaching professional development that faculty reported in the qualitative phase. The questionnaire consisted of 16 Likert-scale type items (1 = Strongly disagree; 4 = Strongly agree). Twelve items related to extrinsic reasons, and thus were considered controlled reasons (e.g., “I had to improve my teaching skills to improve my prospects for tenure” and “My department asked/told me to take this type of training”). The other four items related to intrinsic reasons and thus were considered autonomous (e.g., “I thought teaching was an inherently valuable activity” and “I loved teaching and wanted to improve”). The Cronbach’s alpha reliabilities for the initial autonomous and controlled reasons subscale were 0.79 and 0.75, respectively, and for the recent autonomous and controlled reasons subscale the alpha reliabilities were 0.85 and 0.77, respectively.

Perceived competence for teaching and research sub-survey. STEM faculty members’ competence for teaching and research was measured using the short 4-item Perceived Competence Scale (PCS) developed by Williams and Deci (1996). All items of the PCS subscale were modified to specifically assess participants’ feelings of competence for teaching (e.g., “I
feel confident in my teaching abilities”) and research (e.g., “I am able to research goals”). Respondents were asked to provide judgments about how true they found statements with respect to teaching and research along a 7-point Likert-type scale (1 = Not true at all; 7 = Very true). A participant’s PCS score for teaching and research was calculated by averaging the participant’s responses on the four items for each subscale. The Cronbach’s alpha measures of internal consistency for the perceived competence items for teaching and research were 0.84 and 0.86, respectively.

Data Analyses

Research question 1: Trends in STEM faculty participation in TPD. Descriptive statistics was conducted to investigate the number of STEM faculty that participated in teaching professional development for the full sample and with respect to academic title. To investigate whether the frequency of participation in TPD differed as a function of academic title, chi-square analysis was performed to determine if significant differences existed in TPD participation with respect to academic title. The results of paired t-test analyses, as well as all statistical tests, were deemed significant at the $p < .05$ level.

Research Question 2: Motivations for faculty participation in TPD. The second research question examined the motivation for engagement in teaching professional development reported by all respondents, and with respect to academic title. Mean and standard deviations were calculated for autonomous reasons (AR) and controlled reasons (CR) and paired t-tests were used to determine whether there were any differences between the two types of reasons for all faculty and as a function of academic title. The Relative Autonomy Index (RAI) for each respondent was calculated by subtracting the mean score of CR from the mean score of the AR. Higher RAI scores suggest faculty members are more autonomously regulated (i.e., more intrinsically motivated), while lower scores indicate faculty participation in TPD is less autonomously regulated and more controlled regulated (i.e., extrinsically motivated).

Group differences for autonomous motives (AR), controlled motives (CR), and Relative Autonomy Index (RAI) with respect to academic title were determined using one-way analysis of variance (ANOVA) where AR, CR, RAI were included as dependent variables. To provide a more focused comparison among the three groups for significant ANOVA results, post hoc tests were performed using Turkey’s honest significant difference (HSD) tests. Prior to performing the one–way ANOVA, a Levene’s Test was conducted to verify the equality of variances for each of
the subscale scores and RAI among the groups, \( p > .05 \). Effect size, which represents the magnitude of difference between group means was calculated using Cohen’s \( d \) test (Sullivan & Feinn, 2012). Cohen classified effect sizes as small \( (d = 0.1) \), medium \( (d = 0.5) \), and large \( (d \geq 0.8) \).

**Research Question 3: Barriers to participation TPD.** The third research question explored potential barriers (reported by faculty during the qualitative phase) for real and envisioned participation in TPD with a larger array of faculty, specifically rated by participants who never participated in TPD and those who had participated in only one TPD activity. To make comparisons, agreement was indicated as answering “strongly agree” or “agree,” and disagreement was indicated as answering “disagree” or “strongly disagree.” Percentages of responses for level of agreement and disagreement were calculated to indicate the relative strength of opinion on each of the barriers. For reporting purposes concerning descriptive statistics, we use the following terms to distinguish the percentage of respondents making a claim regarding barriers:

- **Almost all respondents** = 90% or more
- **Vast majority of respondents** = 76–89%
- **Most respondents** = 61–75%
- **About half of respondents** = 40–60%
- **Many respondents** = 25–39%
- **Few respondents** = 11–24%
- **Almost none of respondents** = 10% or less

**Research Question 4: Motivations for initial vs subsequent TPD participation.** The fourth research question explored the differences between motivations for initial and recent participation in TPD for those respondents who participated in at least two TPD activities. Means and standard deviations for autonomous and controlled reasons for both initial and recent participation in TPD were calculated and compared using paired \( t \)-tests. Results of the paired \( t \)-test analyses were deemed significant at the \( p < .05 \) level.

**Research question 5: Perceived competence for teaching and research.** This research question investigated whether there was a difference between perceived competence for teaching and research with respect to academic title and level of engagement with TPD. To answer this question, means and standard deviations for perceived competence for teaching and research
were calculated. The means were then compared using paired $t$-tests to determine differences between the two competencies for all STEM faculty and, specifically, with respect to academic title (assistant, associate, or full professor) and participation in TPD (yes or no). The results of paired $t$-test analyses, as well as all statistical tests, were deemed significant at the $p < .05$ level.

One-way analysis of variance (ANOVA) was conducted to compare perceived competencies in teaching and researching as a function of academic title. Post hoc tests were used to further analyze ANOVA results for significance between more than two categorical independent groups. Independent $t$-tests were conducted to compare perceived competencies with respect to teaching and researching as a function of participation in TPD. Prior to running Independent $t$-tests and ANOVA, the assumption for equality of variance for the competencies scores among the groups was verified using Levene’s test, $p > .05$ (Martin & Bridgmon, 2012). Results of one-way ANOVA and independent $t$-test analyses were deemed significant at the $p < .05$ level.

**Results**

**General Trends in RU STEM Faculty Participation In TPD**

Of the total 227 surveyed STEM faculty participants, 171 (75%) had participated in TPD, and 56 (25%) had never participated in TPD. With respect to academic title, 51 (80%) of assistant professors, 47 (70%) of associate professors, and 73 (76%) of full professors had participated in TPD (see Figure 2). When TPD participants were asked about what point they had participated in TPD, 46 (27%) selected as a graduate student, 116 (68%) selected as a faculty member at a higher education institution, 12 (7%) selected “other” with most then specifying participation in TPD as a postdoctoral researcher. Figure 2 shows the percentage of STEM faculty that engaged in TPD, for all respondents and by academic title.
Figure 2. Percentage of STEM faculty engaged in teaching professional development. Percentages are reported for all respondents and by academic title.

Of the 171 TPD participants, 128 (75%) had participated in more than one TPD activity. Of those who reported participation in more than one TPD activity, 37 (29%) participated in 2-3, 27 (21%) in 4-5, and 32 (25%) in 6 or more TPD activities, respectively (see Figure 3). Chi-square analysis revealed that there was no significant relationship between frequency of TPD participation and academic title ($\chi^2 (2, N=171) = 2.37, p = 0.67$) (see Figure 3).
Figure 3. Number of times STEM faculty engaged in teaching professional development. Percentages are reported for all participants and by academic title.

Motivations For RU STEM Faculty Participation In TPD

The Levene’s test indicated the equality of variances across groups based on academic title for the autonomous (AR) and controlled reasons (CR) subscale scores, and Relative Autonomy Index (RAI) scores ($p > .05$). Table 3 shows the means and standard deviation for the autonomous reasons (AR) and controlled reasons (CR) subscales, and RAI scores for all TPD participants and by academic title. Across the full sample, the correlation coefficients among the items for the autonomous regulation subscale and controlled regulation subscale were 0.81 and 0.72, respectively.

Autonomous reasons. The ANOVA results showed that there was no significant differences in the mean score for autonomous regulation to engage in professional development between assistant, associate, and full professors, $F(2,168)=2.04$, $p = .130$.

Controlled Reasons. The ANOVA results showed that there was a significant difference in the mean score for controlled reasons for participation in TPD between assistant ($(M=2.97$, $SD=.81)$ associate $(M=2.71$, $SD=1.04$), and full professors $(M=2.47$, $SD=.86)$, $F(2,168)=4.71$, $p=.01$, $\eta^2=.05$. Despite this difference, however, the effect size of 0.05 suggests only a small
effect of academic title on the variation in motivation to engage in teaching professional development. Further analysis using the Tukey’s HSD tests showed that the mean scores for controlled regulation were significantly higher for assistant professors compared to full professors ($p = .004$). However, the mean scores for controlled regulation were not significantly different between assistant and associate professors ($p = .169$), and full and associate professors ($p = .172$).

**Relative Autonomy Index (RAI).** The analysis of variance results indicated a significant difference in the RAI scores between associate ($M = 2.69$, $SD = 1.20$), associate ($M = 2.67$, $SD = 1.29$), and full professors ($M = 3.25$, $SD = 1.06$), $F(2,168) = 4.86$, $p = .009$, $\eta^2 = .10$. Despite this statistical difference, however, the effect size of 0.10 suggests only a small effect of academic title on motivation to engage in TPD. The Tukey’s HSD tests showed that the RAI scores were significantly higher for full professors compared to both assistant ($p = 0.028$) and associate professors ($p = 0.037$). However, the RAI scores were not significantly different between assistant and associate professors ($p = 0.937$). (see Table 2).

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Assistant Professor</th>
<th>Associate Professor</th>
<th>Full Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SRQ-L</strong></td>
<td>$n = 171$</td>
<td>$n = 51$</td>
<td>$n = 47$</td>
<td>$n = 73$</td>
</tr>
<tr>
<td><strong>AR</strong></td>
<td>$M = 5.61$, $SD = .93$</td>
<td>$M = 5.66$, $SD = .96$</td>
<td>$M = 5.38$, $SD = 1.02$</td>
<td>$M = 5.72$, $SD = .82$</td>
</tr>
<tr>
<td><strong>ES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Motivations For Initial Versus Subsequent TPD participation. Dependent $t$-tests were performed to compare reasons for initial TPD participation versus most recent TPD participation, for those who had participated in at least two TPD activities. The results indicated no significant difference between autonomous reasons for initial participation and most recent participation, $t(128) = 1.54, p = .13$. However, results indicated that there was a significant difference between controlled reasons for initial versus most recent participation. In particular, means for controlled reasons for most recent participation ($M = 1.89, SD = .48$) was significantly lower than controlled reasons for initial participation ($M = 1.96, SD = .50$), $t(128) = 6.03, p = .00, d = .33$. Across the full sample, correlation coefficients among the items for initial autonomous and controlled reasons subscale were 0.79 and 0.75, respectively, and for recent autonomous and controlled reasons subscale the alpha reliabilities were 0.85 and 0.77, respectively. Table 3 shows the means and standard deviations for each of the subscales, autonomous and controlled, for initial and recent TPD participation.

<table>
<thead>
<tr>
<th></th>
<th>Initial TPD Participation</th>
<th>Recent TPD Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n=129$</td>
<td>$n=129$</td>
</tr>
<tr>
<td>CR</td>
<td>2.69</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td>.92</td>
<td>.81</td>
</tr>
<tr>
<td></td>
<td>2.71</td>
<td>1.04</td>
</tr>
<tr>
<td>RAI</td>
<td>2.92</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>1.20</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td>2.67</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>3.25*</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Note. AR = Autonomous Reasons; CR = Controlled Reasons; RAI = Relative Autonomy Index. * $p < 0.05$. # Small Effect (0.0-0.2).

Table 3

Means and Standard Deviations for Autonomous and Controlled Reasons for Initial and Most Recent Participation in TPD, for STEM faculty respondents
<table>
<thead>
<tr>
<th></th>
<th>Autonomous Reasons</th>
<th>Controlled Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.39</td>
<td>1.96</td>
</tr>
<tr>
<td></td>
<td>.52</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td>3.33</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td>.61</td>
<td>.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.33#</td>
</tr>
</tbody>
</table>

* $p < .05$. # Small to Moderate effect (0.0-0.4)

**Barriers to TPD Participation**

The level of agreement on statements related to barriers to TPD participation indicated by respondents who participated in at least one TPD activity ($n = 42$) and those who had never participated in TPD ($n = 56$) are presented as percentages of most agreed (strongly agree/agree) and least agreed (strongly disagree/disagree). Each barrier-related statement is classified under the following the categories: *research priorities, time constraints, departmental/institutional climate, and personal beliefs and attitudes* (see Table 5). The vast majority of the faculty, specifically those who had either participated in one TPD activity or never participated in TPD, reported high levels of agreement for barriers related to time constraints for their envisioned TPD participation. In particular, 80 (82%) of the 98 faculty respondents agree upon the statement “I do not have time,” and 79 (81%) of 98 agreed with the statement, “If I spend too much time or energy developing my teaching skills, then I will not have time for my research.”

The next most agreed upon statement by most respondents ($n=67; 67\%$) was related to their *personal beliefs and attitudes*. In particular, 67 (67\%) of 98 faculty respondents agreed with the statement, “Becoming a more effective teacher will not provide me any additional financial benefits.” About half of the respondents agreed with barriers concerning their professional identity that was mostly defined by research priorities. In particular, 57 (58\%) expressed agreement with the statement “I am first and foremost a researcher and teaching is secondary to my primary objectives.” About half of the respondents ($n=52; 51\%$) agreed with the barrier statement related to structural constraints, specifically, “It is not offered at a convenient place or time” (see Table 5).

Barrier-related statements concerning climate within the context of their discipline that prioritized research over teaching was agreed upon by about half of the respondents as a barrier for their envisioned participation in TPD. Specifically, 60 (59\%) respondents agreed with the statement, “Development as a teacher is not an activity that my department supports with respect to tenure prospects,” and 54 (55\%) respondents agreed with the statement, “Development as a teacher is not an activity that my department supports for merit raise purposes” (see Table 4).
About half of the respondents (n=52; 51%) agreed with the barrier-related statement related to *time and structural constraints*, specifically, “It is not offered at a convenient place or time.” The least agreed upon statement for barriers for envisioned participation in TPD were related to personal beliefs and attitudes about teaching. For instance, only 6 (6%) of the 98 faculty respondents agreed with the following statements, “Becoming a more effective teacher is not important to me,” and “I do not care how my students view my teaching” See Table 5 for the complete list of most agreed and least upon statement for faculty envisioned participation in TPD (see Table 4).

Table 4
*Barriers to Envisioned Participation in Teaching Professional Development (TPD) Reported by Faculty (N=98) who had never participated in TPD (n=42) or participated in at least in one TPD*

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Strongly Agree/</th>
<th>Strongly Disagree/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agree (%)</td>
<td>Disagree (%)</td>
</tr>
<tr>
<td><strong>Research Priorities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I spend too much time or energy developing my teaching skills, then I will not have time for my research</td>
<td>81</td>
<td>18</td>
</tr>
<tr>
<td>I am first and foremost a researcher and teaching is secondary to my primary objectives</td>
<td>58</td>
<td>42</td>
</tr>
<tr>
<td>If I spend too much time or energy developing my teaching skills, then I will be thought a less legitimate researcher</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td><strong>Time and Structural Constraints</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not have time</td>
<td>82</td>
<td>18</td>
</tr>
<tr>
<td>It is not offered at a convenient place or time</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>I never knew it existed</td>
<td>32</td>
<td>68</td>
</tr>
<tr>
<td>Statement</td>
<td>Yes (%)</td>
<td>No (%)</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>It is not offered at all</td>
<td>24</td>
<td>76</td>
</tr>
<tr>
<td>I think the training will not help me in my teaching</td>
<td>33</td>
<td>67</td>
</tr>
</tbody>
</table>

**Department and Institutional Climate**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development as a teacher is not an activity that my department supports with respect to tenure prospects</td>
<td>59</td>
<td>41</td>
</tr>
<tr>
<td>Development as a teacher is not an activity that my department supports for merit raise purposes</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Development as a teacher is not an activity that my campus/institution supports with respect to tenure prospects</td>
<td>48</td>
<td>52</td>
</tr>
</tbody>
</table>

**Personal Beliefs and Attitudes**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Becoming a more effective teacher will not provide me any additional financial benefits</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>I am already a good enough teacher without need for improvement perceptions</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td>I do not care how my colleagues view my teaching</td>
<td>14</td>
<td>85</td>
</tr>
<tr>
<td>Becoming a more effective teacher is not important to me</td>
<td>6</td>
<td>94</td>
</tr>
<tr>
<td>I do not care how my students view my teaching</td>
<td>6</td>
<td>94</td>
</tr>
</tbody>
</table>

**Perceived Competence for Teaching and Research**
Dependent samples *t*-test analysis to compare means between STEM faculty members’ level of competencies for teaching and research indicated that perceived competence in teaching ($M = 5.76, SD = .92$) was significantly higher than perceived competence for researching ($M = 5.42, SD = 1.10$) for all participants in the sample, $t(227) = 4.14, p = 0.00, d = .34$ (see Table 2). Across the full sample, the correlation coefficients among the items for perceived competence items for teaching and research were 0.84 and 0.86, respectively.

Correlations of academic title with comparisons between perceived teaching and research competencies. With respect to academic title, the results indicated that assistant professors felt significantly more competent to teach ($M = 5.76, SD = .92$) than do research ($M = 5.03, SD = 1.03$), $t(63) = 3.01, p = 0.00, d = .51$ (see Table 2). Similarly, full professors felt significantly more competent at teaching ($M = 5.82, SD = .93$) than researching ($M = 5.45, SD = 1.11$), $t(95) = 2.85, p = 0.005, d = .36$. No significant differences between perceived competence for teaching ($M = 5.66, SD = 1.05$) and researching ($M = 5.47, SD = 1.18$) was observed for associate professors, $t(66) = 1.31, p = .20$ (see Table 4).

Correlations of participation in TPD with comparisons between perceived for teaching and research competencies based on participation in TPD. With respect to participation in TPD, the results indicated STEM faculty who participated in TPD felt significantly more competent to teach ($M = 5.79, SD = .92$) compared to research ($M = 5.35, SD = 1.40$), $t(170) = 4.58, p = .00, d = .66$ (see Table 2). No significant difference between perceived competence for teaching ($M = 5.67, SD = .95$) and researching ($M = 5.62, SD = .96$) was observed for STEM faculty who did not engage in TPD, $t(55) = 0.283, p = .78$ (see Table 4).

Differences in perceived teaching and research competencies within groups by academic title. One-way ANOVA was conducted to compare the effect of academic title on perceived competencies with respect to teaching and researching. There was no significant difference in means of perceived competence in teaching and researching with respect to academic title, $F(2, 224) = 0.64, p = 0.53$, and $F(2, 224) = 0.53, p = 0.59$, respectively (see Table 4).

Differences in perceived teaching and research competencies within groups by participation in TPD. An independent *t*-test was conducted to compare perceived competencies with respect to teaching and researching between respondents who had participated in at least one TPD and those who had never participated in TPD. There were no significant differences in
means of perceived competencies with respect to teaching, \( t(225) = 0.81, p = 0.42 \) and researching, \( t(225) = 1.63, p = 0.11 \), between TPD participants and non-TPD participants (see Table 5).

Table 5

*Means and Standard Deviations for Perceived Competence for Teaching and Research for All Respondents, by Academic Title, and by TPD Participation*

<table>
<thead>
<tr>
<th>Academic Title</th>
<th>Teaching Competence</th>
<th>Research Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( n )</td>
<td>( M )</td>
</tr>
<tr>
<td>All</td>
<td>227</td>
<td>5.76*</td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>64</td>
<td>5.76*</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>67</td>
<td>5.66</td>
</tr>
<tr>
<td>Full Professor</td>
<td>96</td>
<td>5.82*</td>
</tr>
<tr>
<td>TPD participation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>171</td>
<td>5.79*</td>
</tr>
<tr>
<td>No</td>
<td>55</td>
<td>5.67</td>
</tr>
</tbody>
</table>

*\( p < 0.05 \). # Small to Moderate effect. ## Moderate to Large Effect.

**Study Limitations.**

I must pause to note the limitations of my study. Although a sequential mixed methods design used for the overall study was best suited for exploring rarely investigated phenomena related to faculty motivation to participate in TPD, various aspects of this study suggest it should be treated as exploratory. The small sample size, low response rate, and potential for sample self-selection limits the potential generalizability of findings. While survey design often poses reliability and validity issues, I acknowledge added limitations in not conducting cognitive
interviews with sample populations, to explore the ability for respondents to comprehend the survey items. As well, only one round of piloting was done on the original survey and no pilot was performed on the slightly modified final version of survey. As such, I view my study as a first step into exploring these issues regarding and efforts to motivate faculty participation in TPD for the crucial population of research university tenure-track STEM faculty.

**Discussion, Implications, and Potential For Future Research Directions**

This paper details an investigation within a larger study exploring research university (RU)-based STEM faculty members’ patterns of participation in teaching-related professional development (TPD), their motivations to participate in TPD, barriers to envisioned participation in TPD, and overall professional competence with respect to teaching and doing research as it relates to participation in TPD. Drawing on multiple theoretical perspectives, mainly affordance theory, self-determination theory (SDT) of human motivation, and the qualitative phase findings of the larger study, I now attempt to illumine the findings I discovered via this part of my dissertation work.

**General Trends in RU STEM faculty participation in TPD**

The vast majority of RU STEM tenure-track faculty who participated in the quantitative phase of our larger study (the subject of this chapter) participated in TPD. In fact, almost all of our survey respondents had participated in more than one TPD activity. No differences in TPD participation were noted across academic title. This indicates, at least for our self-selected sample, that STEM faculty may often be willing to participate in TPD. The fact that many had participated in many TPD events indicated that they may also be drawn back to TPD, perhaps as Bouwma-Gearhart found in her dissertation study (2012) per their discovery of TPD as helpful in meeting their professional needs (addressed in better detail later). A common assumption among the research community is that STEM faculty members care less about teaching and more about research. It is evident in my findings that faculty value teaching and are often intrinsically motivated to improve their teaching practices. In spite of feeling very competent in their teaching, they choose to participate in professional development activities. Another common assumption shared by many researchers and TPD developers is that faculty who participate in TPD are intrinsically motivated to do so, and that those who do not, or who might require externally motivating factors to be encouraged to do so, are a lost cause (Bouwma-Gearhart, 2012).
At the same time, although faculty members may be intrinsically motivated, faculty are very much aware of institutions and departmental norms that limit their actions toward improving teaching. Institutional and departmental culture that does not recognize teaching for tenure and promotion prospects was indicated as a significant barrier towards their teaching improvement. This finding suggests that even though faculty are inherently interesting in learning about new practices or in fact aware of effective practices, they may not seek support to implement these practices in their classroom because of the fear of being perceived as someone who cares more about teaching and less about their responsibilities as a researcher. Therefore, those attempting to improve teaching at RUs should note that many faculty members may be inherently interested in teaching and are motivated into this important action by both intrinsic and extrinsic factors. It is through continued participation in TPD that they become less motivated by external outcomes and more motivated by internal factors. Acknowledging my relatively small sample and potential self-selection bias in sampling, future research to explore faculty motivation to improve teaching practices with a greater number of faculty is warranted.

In fact, this fear may go as far back as their graduate school training. In fact, few faculty in my study had participated in TPD during graduate school, including the most newly minted professors at the assistant level. This finding calls to attention the need to further advance the recommendations of researchers who have advocated for the strategy for TPD for doctoral students on their way to fill faculty positions (Austin, Campa, Pfund, Gillian-Daniel, Mathieu, & Stoddart, 2009). While I know of numerous TPD efforts targeting graduate students, including those in STEM disciplines, at RUs (i.e. the Center for the Integration of Research, Teaching and Learning (CIRTL) network, http://www.cirtl.net/; the national Preparing Future Faculty (PFF) program, http://www.preparing-faculty.org/), there seemed no indication on the part of our sample that these efforts have yet afforded widespread impact. Prospective faculty need opportunities to engage in TPD to help them understand all facets of faculty work, especially related to teaching. The lack of TPD participation during graduate school across our sample confirms Austin and colleagues’ (2009) notion that graduate students receive conflicting messages about what is important in their careers and where to put emphasis in their preparation. While graduate student-preparing institutions may pay lip-service to the importance of their teaching missions, other influences, such as faculty advisors, may urge graduate student to avoid spending too much time on teaching preparation in order to ensure their greater research
productivity (Austin et al., 2009; Connolly et al., 2015). To increase participation in TPD, STEM improvement efforts at RUs need to consider how to motivate graduate students, and the individuals and systems that support them and often determine their felt autonomy regarding professional decisions, to prepare them to prepare to excel at teaching as well as research.

**Motivations for RU STEM Faculty Participation in TPD**

Far from operating from culture models that assume RU STEM faculty do not consider the need to improve their teaching practices, or consider in engaging in typical means to do so, our sample of STEM faculty were interested in improving their teaching practices. In fact, they were often intrinsically motivated to do so; yet other externally influenced factors seemed to hold potential as critical levers towards TPD participation, especially their earliest participation. For our sample, STEM faculty participation in TPD was regulated by autonomous as well as controlled reasons. Simply stated, faculty participation in TPD was influenced by both intrinsic and extrinsic motivation. The various forms of motivation driving action, in this case participation in TPD, supports SDT’s prediction that a person’s actions are not always driven by one form of motivation (Deci & Ryan, 1985). A closer look at the results highlights that, overall for our sample, STEM faculty were more intrinsically motivated than extrinsically motivated to engage in TPD, with no differences based on academic title.

These findings suggest that some faculty may have both participated initially in TPD per assumptions that they would find TPD to be inherently interesting and enjoyable. However, it is important to note that although faculty in our sample were more autonomously regulated to participate in TPD overall, controlled reasons also influenced their participation. Some faculty, especially initially, also pursued TPD to satisfy more external demands, included issues associated with their ego (e.g., embarrassment resulting from reading students’ lackluster evaluations of their teaching) and/or obtainment of rewards associated with improvements to teaching (e.g., financial awards). Thus, some faculty may have discovered TPD, per their earliest TPD engagement that was more extrinsically motivated, to be more interesting and enjoyable. For these faculty, participation in TPD could have been spurred by their internalizing of the value of TPD activity per their earliest participation, an explanation that would be consistent with Bouwma-Gearhart’s (2012) qualitative phase findings who found, across her 12 research participants, that RU STEM faculty members’ initial participation in TPD to be almost exclusively extrinsically motivated, with subsequent participation fueled by what SDT theorist
term *internalization* of an activity’s importance, rendering subsequent motivation akin to more intrinsic types.

Although autonomous reasons were more salient, across the board, for our sample than for the smaller sample of Bouwma-Gearhart’s (2012) study, it is important not to overlook the potential influence of faculty members’ controlled reasons for TPD participation. Extrinsic forms of controlled regulation, such as such as rewards or fear of punishment, as well as introjected forms, such as feelings of guilt and ego, seemed salient for our sample as well. As Bouwma-Gearhart found in her 2012 study, some faculty may indeed internalize the importance of an activity originally engaged in per more controlled regulation forms of motivation. The survey findings reported in this paper may strengthen Bouwma-Gearhart’s 2012 claim that engagement in one or two meaningful TPD experiences may shift faculty members’ motivation from the more extrinsic to the more intrinsic, with recognized importance of TPD activity driving subsequent participation. For her small sample, when faculty needs for competence, relatedness, and autonomy concerning teaching were being met through participation in TPD, they internalized the worth of TPD activities and they become more intrinsically motivated to engage in TPD (Bouwma-Gearhart, 2012).

Indeed, one of the most interesting findings of my study concerns motivations for initial participation in TPD versus most recent participation in TPD regardless of rank. While autonomous reasons (e.g., personal interest) as well as controlled reasons (e.g., rewards) influenced faculty’s initial and most recent participation in TPD, with time controlled reasons for participation in TPD significantly decreased. I feel this finding can serve as a critical piece of information for STEM education initiatives. For one, this finding may be explained by a diminishing concern on the part of faculty regarding external factors. Perhaps, even, the influence of the culture/climate of STEM units may decrease for these individuals over time for some reason. While we cannot say if this is true, or even why it is true, but further confirmation of such, or of faculty members’ diminishing concern for external factors generally speaking, may hold implications for change initiatives insistent on and investing resources in changing unit culture.

At the same time, my findings that hint at the power of external factors, perceived as affordances by faculty, in motivating RU STEM faculty to engage in TPD varied across stage in career. Indeed, per my data, assistant and associate professors may be more motivated to engage
in TPD by controlled reasoning/externally motivating factors. As Bouwma-Gearhart found in her 2012 study, when a faculty member’s teaching is deemed problematic by enough external stakeholders (students and especially colleagues), those on the tenure-track are likely to give their teaching more attention, considering that their teaching may, in fact, be taken into consideration for tenure prospects. This reality could be why assistant professors indicated they are more likely to be influenced by external outcomes to improve teaching. They may pay more attention to how their teaching is perceived by others (i.e., external regulation) because of tenure prospects. Full professors, on the other hand, reported the lowest level of controlled reasons for their participation in TPD. Full professors’ relative autonomy index (RAI) score was significantly higher than the assistant professors’ score, suggesting that they were more autonomously regulated to participate in professional development. These findings might help confirm the assumptions of many TPD proponents that full faculty members’ ability and willingness to engage in TPD correlate with the number of years they have spent in their profession and, more directly, to the professional hurdles they have already accomplished and not presenting as external barriers.

Full professors are typically tenured and are at a point in their career during which their research is most likely well (enough) established. They are less likely than more junior counterparts to be concerned about job security in an environment that emphasizes research over teaching. Full professors may also be more autonomously regulated compared to associate and assistant professors because of the various factors in the sociocultural environment supportive that affords them opportunities to feel autonomous. After meeting all the tenure and promotion regulations, institutions and departments are more likely to let full professors define their professional identities. These supportive potential and policies may be perceived as affordances for their participation in TPD. At this point in their career, they may believe that they have proven themselves to be competent in their work, as researchers, which in return affords them the opportunities to an autonomy-supportive environment. Based on self-determination theory, when an individual feels more autonomous they are more like to participate in an activity for intrinsic reasons and less for controlled reasons. While future study would be needed to confirm this more nuanced speculation, my findings may support initiative theories of action that include full professor leadership in achieving undergraduate STEM education improvements.

Overall, my results related to motivations of RU tenure-track STEM faculty for TPD
participation hold great value for faculty developers and other stakeholders who are concerned with how to increase faculty participation in TPD. Leveraging externally motivating factors, such as stipends and potential for teaching awards, may be a key strategy to increase RU STEM faculty members’ participation in TPD. Contrary to the common assumption that nothing can be done to get RU tenure-track faculty to learn about effective practices via participation in TPD (Huber & Hutchings, 2005; Owens, 2001; Wallen, 2001), my study indicates that extrinsic factors such as rewards and more introjected forms of external factors, such fear of punishment, may encourage faculty to participate in TPD. Once faculty members’ needs for competence and autonomy are met via participation in TPD, they may in fact perceive required training more like an affordance and less like a constraint. Required participation in TPD may help those who are actually interested in teaching, and may be afraid to openly express their interest in improving their teaching skills and knowledge. Perhaps for those faculty whose identities are shaped by their teaching roles, in addition to their research roles, mandated time might allow them to invest time towards becoming their best professional selves without fear of professional retaliation. As such, policies making TPD mandatory, although perhaps initially perceived as an aggressive or punitive, as top-down edict, may actually encourage faculty participation in TPD. Testing of this hypothesis is one direction that I offer for future research.

Influence of Participation in TPD on Perceived Teaching and Research Competence

My study reveals that RU STEM faculty participation in TPD is correlated with increased competence in teaching compared. This finding is somewhat consistent with Connolly and his colleagues’ (2015) study on impact of teaching professional development on RU STEM graduate students’ college teaching competence. Connolly and his colleagues suggested that participation in TPD programs positively impacts early-career academics’ teaching competence. As time spent in TPD increases, so does the benefit to the participant (Connolly et al., 2015). Bouwma-Gearhart argued similarly regarding RU tenure-track faculty in her small qualitative study of RU tenure-track STEM faculty in 2012. Given the potential of TPD activities, including increased competence for teaching and desire to continue engaging in TPD work, I suggest, as did Bouwma-Gearhart in 2012, that policymakers and funders should continue support for TPD programs targeting RU STEM faculty, that utilize strategies that also include externally-based rewards and incentives to encourage TPD participation.
As mentioned in the above section (and first argued by Bouwma-Gearhart in 2012), once faculty members’ needs for some teaching competence are met via participation in TPD, regardless of initial reasons for motivation, they may be more likely to participation in subsequent TPD activities. In turn, each meaningful TPD experience may afford additional means for the continuous reflection and practice improvement indicative of strong educators (Barr & Tagg, 1995; Loucks-Horsley, Stiles, Mundry, & Hewson, 2000; McAlpine & Weston, 2000). If this explanation is accurate, change initiatives affording potentially modest external motivating factors (e.g., rewards and funds) or just leveraging preexisting external factors requiring little additional resource (student evaluations of teaching scores) might realize large benefits in the long run. External affordances may encourage faculty to attend to their teaching needs and may in fact motivate them to engage in TPD. This strategy may be especially important for early-career faculty, who are more motivated by external factors and who notably feel less competent with respect to their teaching practice.

**Perceived Barriers and Affordances for Participation in TPD**

Alongside the hope I felt regarding the findings discussed above, my findings indicate that significant barriers to RU STEM faculty participation in TPD are still at play. As noted by our respondents, both non TPD participants as well as those who had participated in at least one TPD event, lack of time and a negative culture in STEM departments and colleges (in not valuing good teaching or TPD) were put forth as barriers for participation in TPD, a finding discussed elsewhere in the literature (Brownell & Tanner, 2012; Henderson & Dancy, 2007; Henderson, Finkelstein, & Beach, 2010). For example, Henderson and Dancy (2007) report that faculty are sometimes too busy with research responsibilities or teaching loads to have the time to learn about new teaching techniques. In addition, department norms that push faculty to focus more on research and less on teaching has been found to be major barrier to faculty participation in TPD (Brownell & Tanner, 2012). My findings confirm the need for the general theory of action that underlies various postsecondary STEM education improvement initiatives, actively advocating for and attempting to change the culture in STEM departments at RUs. My findings also point to potential success of initiatives that might provide teaching release time for those wanting to spend time engaged in TPD activities, as well as those that may promote release time from research obligations for faculty engagement in TPD, the later strategy that currently seems unheard of among institution- or nationally-focused initiatives, but that may be a successful
strategy at the unit (e.g. department or college) level. Future inquiries may wish to explore undergraduate STEM education improvement initiatives that afford alleviations to the barrier of educator time, including theories of action that provide “time incentives” to tenure- and non tenure-track faculty both.

As detailed above, while not directly measured as an affordance for TPD participation, my findings on the diminishing impact of external factors in motivating participation with subsequent participation, as well as advanced stages in career, point to a key affordances of TPD participation, those being previous TPD experiences, however initially motivated (as argued by Bouwma-Gearhart in 2008 via a much smaller sample), as well as time and advancement towards realizing the title of full professor (a new finding per my research). As well, my findings point to the affordance of externally motivating factors (i.e. mandates, awards) to inspire earlier career faculty TPD participation (as also argued by Bouwma-Gearhart in 2008). My findings concerning faculty motivation to engage in TPD also seem to confirm additional theories of action underlying other undergraduate STEM education improvement, namely those promoting factors that may elicit external motivation to engage in TPD. These include an initiative of the Association of American Universities (2011), that encourages universities to recognize outstanding teachers with modest monetary awards and a special title of recognition. In addition to campus recognition, some initiatives advocate for departments to provide rewards and incentives to support scholarly activities, such as practitioner research, to recipients who demonstrate excellence in teaching (e.g. the AAU STEM Education Improvement initiative, 2011; Handelsman et al’s Scientific Teaching initiative, 2009; Weiman’s SEI initiative, 2009).

Alongside more immediate external motivators, some of these initiatives are promoting transformation of the formal criteria for tenure and promotion at RUs, to more equally value teaching and scholarship (Anderson et al., 2011). The results from this study clarify that the external conditions that STEM education initiatives are addressing to make it more conducive for faculty to focus on teaching do in fact play an influential role in encouraging faculty to focus on improving their teaching particularly through their engagement in TPD.

**Conclusion**

At a time when improving undergraduate STEM education is an urgent national need, emphasis on teaching-related professional development for research university faculty is a necessity. Understanding faculty motivation to participate in TPD is essential for change agents,
higher education leaders, and disciplinary societies towards best planning and promoting improvement initiatives theories of action, to best align with faculty realities. My research indicates that TPD opportunities must tap into both faculty members’ intrinsic and extrinsic motivations, via affordances of their professional environments that factor into faculty members’ sensemaking with respect to their most pressing needs and interests. Without attention to these realities, faculty will not only lack motivation to participate in TPD, but they will resist and resent it, reducing the potential for learning and leading to a negative impact on the culture of the organization (Deci & Ryan, 2002).

CHAPTER IV

Conclusion

The underlying aim of my dissertation was to add to the field of knowledge to better support and foster STEM education improvement initiatives at public research universities. I contend that my two research manuscripts advance knowledge per perspectives of key
stakeholders targeted by initiatives attempting to foster such change, students and faculty. In the first manuscript, I explored undergraduate students’ perspectives on undergraduate STEM education at research universities (RUs), generally speaking, and concerning teaching-related factors in STEM courses, with enhanced attention to students’ felt affordances for their learning and engagement in STEM. In the second manuscript, I explored tenure-track faculty members’ engagement in teaching-related professional development (TPD), barriers to participation in TPD, and their motivation and related competencies associated with TPD.

**Considering Students’ Perspective**

In my first empirical study, Chapter 2, students were given an opportunity to share, in their own words, their perspectives on the undergraduate STEM education environment at RUs, and teaching practices and other factors concerning pedagogy in STEM courses, specifically. This study is especially timely, given the ultimate goals of change initiatives attempting to improve undergraduate STEM education, as well as the reality that students’ perspectives continue to be overlooked, in both research that could inform these change initiatives, as well as during decision-making and strategic planning concerning undergraduate STEM education programming and practices. I assume the notion that undergraduate students have perspectives that need to be considered in discussions related to educational practices and their improvement, as well as the assumption that these students are expert informants of their educational experiences, who can convey these perceptions (Cook-Sather, 2002). In addition, I also assume that students’ actions (including the learning and engagement that initiatives desire to better) cannot be studied in isolation from the individual’s environment (Gibson, 1979). As such, this student-focused study is grounded in Gibson’s (1979) theory of affordances, or the opportunities for individuals’ actions based on their perceptions of the environment, and various theorists notion of sensemaking (Letcher & Lissack, 2009).

The findings that emerged from this student-focused study provide a descriptive overview of students’ perceived constraints and affordances for their success in STEM disciplines, with *success* being defined as their *learning* and *engagement* in STEM. The most significant constraint noted by students was what they perceived to be the poor quality of instruction they encountered STEM classroom environments. More specifically, STEM faculty who do not value teaching and who were not interested in making the efforts to teach more effectively were perceived as constraints for students’ learning and engagement in STEM
courses. Interestingly, students largely attributed these faculty characteristics to the unfavorable academic culture that glorifies research productivity at the expense of teaching effectiveness. In fact, students noted that the unfavorable culture influenced was a major barrier for why faculty lacked the motivation to improve their practices.

With respect to teaching practices, specifically, an overwhelming majority of the students in the study deemed “pure lecturing,” during which instructors talk continuously while students have to passively receive information, as a constraint to their learning and engagement. Yet there is evidence, both anecdotal (Weiman et al., 2009) and empirical (Hora & Ferrare, 2013; Hora, 2014) that this form of instruction continues to be the dominant way undergraduate students are taught in STEM courses (Handelsman, Miller, & Pfund, 2009; Mazur, 2013; National Research Council, 2012). A plethora of perceived affordances concerning pedagogical practices and other factors were noted by students, beyond just favorable teaching methods (e.g., group work). In addition to specific teaching methods (e.g., small group work), other affordances included a variety of more general teaching methods (e.g. interactive lectures), instructional strategies (e.g. use of illustrations), students’ cognitive engagement opportunities (e.g., connections to real world), additional physical/technological resources (e.g., notes), and instructor personality traits (e.g., enthusiasm). In fact, the perceived affordances of students, take together, present teaching as a complex and multifaceted practice. Students’ perspective on teaching align with the thinking of several researchers who advocate for teaching to be studied as a complex and multidimensional phenomenon. Students in my study, additionally, articulated teaching in ways that confirms what is known about best practices in the fields. For instance, students’ perceived critical thinking and cognitive engagement as important aspects of learning, and they preferred faculty who encouraged these practices in the classroom.

I offer several implications concerning improvement of STEM education as a result of this student-focused study. First, and most importantly, conversations concerning teaching practices in STEM classrooms (including its improvement) need to be informed by the nuanced and perceptive perspectives of students. Additionally, efforts focused on better understanding and assessing postsecondary teaching need to consider descriptive rather than evaluate approaches, that enables documentation of the more complex dynamics between teachers, students, and technologies in the classroom, that intertwine and present as affordances for students’ learning and engagement.
Considering Faculty Perspectives

My second research study (Chapter 3), is part of a larger mixed methods study focused on empirically investigating STEM faculty members’ experiences participating in teaching-related professional development (TPD), motivation and factors inspiring, and discouraging, their participation in TPD, and professional competence with respect to teaching and doing research and in relation to TPD participation. As faculty work is influenced by the departmental and institutional context within which they are situated, it was important to examine how faculty perceptions of the environment influenced their envisioned participation in TPD (Turper et al., 2015). Similar to the student-focused study, this faculty-focused study is grounded in theories of affordances and sense-making (described above). Applied to the context of my study, the pertinent affordances for faculty members’ were aspects of the environment within which they work (norms, policies, priorities, etc) viewed as potentially supportive or delirious for their envisioned participation in TPD.

To explore STEM RU faculty members’ experiences and motivation to participate in TPD, I also used Deci and Ryan’s (1985) well-test theory of motivation, *self-determination theory* (SDT). According to SDT, humans coordinate their actions to satisfy three basic psychological needs, a more unified sense of self (*autonomy*), better understanding and ability to react to the world around them (*competence*), and better social integration (relatedness). Based on the extent to which the social environment supports or constrains the satisfaction of the three basic psychological needs, human beings can either be regulated by *autonomous* or *controlled* motives to engage in a task (e.g, TPD) (Deci & Ryan, 1985). *Autonomous reasons* involve an individual’s felt sense of choice and acting with a sense of volition or willingness (Deci & Ryan, 2000). On the other “side” of the motivation spectrum is *controlled reasons* that involves an individual who obeys a rule solely for fear of punishment that would otherwise result, is exhibiting the most extreme form of *controlled regulation*, in which one feels no, or very little, autonomy to participate in the activity (Deci & Ryan, 2000).

In the qualitative phase of the study, conducted by my research advisor, Dr. Jana Bouwma-Gearhart, explored the phenomenon of faculty motivation to engage in TPD with twelve STEM faculty members employed at a large public research university. Bouwma-Gearhart (2012), found that faculty experiences with and motivations concerning TPD resonated with SDT as a theory of motivation. Specifically, findings supported SDT’s prediction of the
correlation between three inherent needs of autonomy, relatedness, and competence, and RU STEM faculty motivation to engage in TPD. In my study, using quantitative survey methods, I explored faculty members’ motivation for both earlier, versus subsequent, TPD participation, as well as relative competence for teaching and researching with a greater number of STEM faculty at three public RUs. With respect to these foci, I also looked at differences based academic title (i.e. point in career), specifically assistant, associate, or full professors.

Overall, my results revealed that most STEM faculty in the study participated in TPD and many via multiple TPD experiences/activities, even in the face of typically cited barriers of lack of time and unfavorable institutional/departmental culture. Additionally, their participation in TPD was mostly regulated by autonomous reasons compared to controlled reasons. However, controlled were still significant, especially for earlier-career faculty, and reduced with subsequent TPD participation. The most common barriers reported by STEM faculty was concerning lack of time and unfavorable institutional/departmental culture. Lastly, my results indicate that all faculty, regardless of academic title or participation in TPD, had a higher level of competence for teaching compared to their competence for research. However, investigation also revealed those who participated in TPD felt more competent to teach compared to those who did not participate in TPD and that full professors felt more competent to teach compared to associate and assistance professors.

I argue for several implications concerning instructional change and faculty motivation to engage in TPD. I recommend those promoting STEM faculty teaching improvement, and participation in TPD specifically, not assume that research faculty do not care about teaching nor typically avoid participation in TPD. Also, key stakeholders must be cognizant that RU STEM faculty may be motivated to participate in TPD for both external and internal factors. My findings indicate that leveraging external factors, such as offering rewards or time release, could potentially afford faculty members’ earliest participation in TPD, and especially for earlier career faculty. In comparison, these external factors affordances may not necessarily be a driving factor for full professors, or others who have already internalized the value of TPD towards strengthening their professional identity as a teacher. Lastly, given that TPD was associated with numerous benefits including increased competence for teaching, and encourages faculty to meet their professional identify needs, policymakers and funders should continue support for TPD.
program as well as the strategy of providing rewards and incentives perceived by so many faculty as affordances for their TPD participation.

Looking Across the Two Studies

An overarching theme that emerged from both studies pertains to the academic culture at RUs in the STEM disciplines. Both students and faculty perceived, and lamented, the unfavorable culture that glorifies research accomplishments at the expense of teaching effectiveness. These findings confirm the theories of action underlying various postsecondary STEM education improvement initiatives that target RU STEM organization (departments’ or colleges’) cultural transformation. My findings also implicate action on the part of postsecondary STEM education unit leaders, who, as noted by several researchers (e.g., Anderson et al., 2011; Weiman et al., 2009), play a key critical role in creating a culture that values and supports both researcher and educator professional identities of a faculty as well as is responsible for distributing and requiring enactment on knowledge regarding best teaching practices for student learning and engagement.

My dissertation findings also inform policies, future practices, and research concerning postsecondary STEM education, especially at RUs. Results from this study call to attention the importance of engaging students and students in conversations and considerations related to educational practice and related improvement efforts. As the ultimate deliverers and recipients of higher education, faculty and students’ perspectives are meaningful and necessary in informing postsecondary STEM education efforts. When external environment is perceived with affordances to improve pedagogical practices, faculty will more likely participate in TPD that promote research-confirmed effective teaching practices. When faculty implement effective practices that place students at the center of practice, the classroom environment will be packed with affordances that support student success within the walls of the university and beyond.

Suggested Future Research Directions

My dissertation research also implicates future research directions. Taken together, my two studies shed light on the experiences of two key stakeholders, students and faculty, by examining how the environment in which they are embedded influences their behaviors and actions regarding their learning and overall success as individuals. Yet my student and faculty samples were limited, by number and at just three RUs. Future research could involve a large-
scale national study focused on institutional transformation at RUs, specifically to uncover how to support the success of students and faculty interacting there.

Considering my methodological approaches, future work could aim at systematically and empirically studying, through mixed-methods, constraints and affordances perceived by all stakeholders including deans, chairs, academic staff support, faculty and students, at RUs regarding issues related to faculty work and student success. As well, I advocate for a qualitative studies to 1) examine the results of the engagement of students in planning and implementing of improvement efforts focused on teaching improvements, 2) to identify reasons for why students, especially underrepresented groups in STEM, continue to persist in STEM majors in spite of perceive barriers, and 3) using descriptive observation protocols, examine whether what students perceive as affordances related to teaching-related practices is actually being used in STEM classrooms. I believe that all of these potential areas of investigation would represent worthy directions for future STEM education research, as each would shed light on potential factors perceived as assets, that can be capitalized on, and barriers that can be remedied, ultimately towards strategic improvement of institutions and STEM organizational units towards better supporting of faculty work and student success in STEM.
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APPENDICES
Appendix A

Email Sent to Deans and Chairs about the TPDM Study

Dear Dr. _______________,

My name is Jennifer Collins and I’m a PhD student working with Dr. Jana Bouwma-Gearhart in the Department of Science Education at OSU where we focus on postsecondary teaching and learning. We are currently part of a UW-Madison based National Science Foundation (under Award No. 1224624) sponsored research project where we’re studying how the undergraduate curriculum is designed in engineering, math, and science disciplines at 3 research universities in Canada and the U.S. Our team is planning on collecting data at [University Name] in mid-May, and I wanted to get in touch with you to let you know more about the study and to see if you had any questions or comments about it. I also wanted to ensure that you were OK with this study proceeding in the College of Engineering, and to see if you have any recommendations for people to speak to about the curriculum at the programmatic level that would be greatly appreciated. In a nutshell, our study is focused on what types of information and resources are used when the undergraduate curriculum (e.g., required courses, content covered in these courses, etc.) is designed by either departmental administrators, curriculum committees, or others. We’re curious if information about things like student achievement data or disciplinary benchmarks/standards are considered as part of this process, and generally how this process unfolds in different disciplines (more information about the study is at: http://tpdm.wceruw.org).

In addition to studying this process of curriculum design at the programmatic level, we’re also looking at how faculty who are teaching lower-division courses in the current term plan their courses and then teach them, for which we’ll be interviewing the faculty and then observing two of their classes. We will be inviting instructors who are teaching courses this term and they will choose whether to participate in the study or not. For each of the courses we’ll also be administering a survey to students about their experiences in the class and conducting a focus group with a sub-sample of students in the course. All student data will be anonymous and held in strict confidentiality. We’re collecting these data for two reasons: first, to examine them on their own merits as part of our research program on teaching and learning, and second, to see if these data are of any use to curriculum planners.

As part of the latter process we hope to provide de-identified reports of our data to those people we interview about the curriculum (at the departmental level) and re-interviewing them in Years 2 and 3 of the study to see if our data are at all useful in enhancing the design process. These reports would aggregate all data from the 4-5 courses we study into a single dataset. The idea is to field-test the prospect that some of our data could be useful in conjunction with the traditional end-of-term evaluations, course-specific assessments, and other types of data. But, if the provision of these data would at any way interfere with departmental procedures we would of course not wish to do so and could simply analyze these data for our own research purposes. (The research project has been approved by the OSU and UW-Madison IRBs)

Thank you for your time and please let me know if you have any questions, comments, or good contacts regarding the undergraduate curriculum.

Sincerely,
Jennifer Collins
Appendix B

Initial Email Sent to STEM Faculty to Request Participation in TPDM Study

Dear Dr. _______________

My name is Jennifer Collins and I am a researcher working with Dr. Jana Bouwma-Gearhart in the Department of Science Education at the Oregon State University. I am writing to ask you to participate in a study about teaching and learning in the STEM disciplines sponsored by the National Science Foundation under Award No.1224624 (http://tpdm.wceruw.org). You have been selected because you are currently listed as an instructor for an undergraduate biology course.

Our study is examining how undergraduate programs and courses are designed in mechanical engineering, biology, chemistry, physics, and ocean/earth/atmospheric sciences departments at OSU and two other research institutions in the U.S. and Canada. Specifically, we are investigating what types of data or other resources (e.g., accreditation criteria) are considered when planning programs or courses. For this study we are interviewing curriculum committee members and program coordinators about department-wide processes, but we also are interested in how individual courses are planned and taught. This part of the study will entail our research team conducting brief 30-minute interviews with instructors at OSU, and observing 2 different lectures in mid-May.

The interview will be focused on issues related to your course planning and the factors that influence your teaching. For the classroom observations, I or one of our research team members would sit at the back of the lecture hall and take notes using a web-based instrument (i.e., no video-taping). In addition, we will be administering an anonymous survey to students in the course about their study habits, and recruiting 5-6 students for focus groups for a sub-set of courses. Data will be collected and stored in a way that ensures individual responses will remain anonymous and confidential during the entire research process and thereafter.

As part of the study we also hope to provide de-identified reports of our data to those people we interview about the curriculum (at the departmental level) and re-interviewing them in Years 2 and 3 of the study to see if our data are at all useful in enhancing the design process. These reports would aggregate all data from the 4-5 courses we study into a single dataset in order to maintain the anonymity of all research participants. The research project has been approved by the OSU IRB, and we have been in touch with your department chair about the study.

I’m currently scheduling interviews and observations for the week of May 13-17 with instructors at OSU and would greatly appreciate your participation in the study. I recognize that your schedule is very busy so we would be happy to speak with you at a place and time that is convenient for you. If your schedule permits participation, please email me with a time that works for you the week of May 13-17 and we can schedule the interview. Also, if you can send along information about the dates, times, and location of the class you’re currently teaching that would be very helpful.
Your participation in this study would be of great assistance to our research project and to the field of higher education’s understanding of curriculum design and the role of data in curricular decision-making. In addition, if you would like to receive your classroom observation data that could be arranged. Thank you for your time.

Sincerely,
Jennifer Collins
Appendix C

Sample Email Message Sent to Students from Course Instructors to Request Participation in Focus Groups

Dear Instructor,

Please send the following message to all your students as soon as you can (all you need to do is copy and paste the following message in your email)

“Dear Students,

A group of researchers from the University of Wisconsin-Madison and Oregon State University are conducting a study about the study habits of undergraduate students in science disciplines at 3 research universities, one of which is [University Name]. This course is being included in the study, and as part of the study the researchers are holding focus groups with students to talk about their study habits, preferences for teaching styles, and related topics. The researchers are holding a focus group for this course on May 17 (Friday) from 2:00-2:45 pm in [Location]. Participants in the focus group will receive $10 for their time, and food will be provided. All data from the focus group will be held in strict confidentiality. If you're interested in participating in the focus group, please contact the project assistant, Jennifer Collins at colljenn@onid.orst.edu and please indicate the course name, [Course Name and Section No.].”

Thank you very much.

Sincerely,
Jennifer Collins
Appendix D

Human Subjects Informed Consent Agreement for Focus Groups
TPDM Study: Spring 2013

With funding from the National Science Foundation, researchers from UW–Madison are conducting a study to identify the individual, disciplinary and organizational factors that shape course planning and classroom instruction. Findings will help inform the design and evaluation of faculty development and pedagogical improvement projects. The study is the Tracking the Processes of Data Driven Decision-Making (DDDM) project, and is funded under the NSF TUES program under Award No. 1224624.

This focus group will require approximately 45 minutes to complete. Your participation is voluntary. There is no penalty or loss of benefits for nonparticipation; you may end your participation at any time without penalty or loss of benefits. By participating, however, you will provide valuable information that may contribute to the improvement of science, technology, engineering, and mathematics (STEM) education reform efforts. Data collected during the focus group may be aggregated and provided to administrators and/or program leaders at your institution.

There are some risks in participation, because if the data were made public, they could be used in a performance evaluation and/or damage a participant’s reputation. To minimize these risks, all data will be held confidential, stored in a secured office, and on a secured computer network. Only the research staff on the DDDM project (i.e., Principal Investigators and project assistants) will have access to the data. Confidentiality will be maintained during the data analysis and writing phases by not using names. However, confidentiality cannot be guaranteed within the focus group as other participants will hear and see what you say.

There are no direct benefits to participating in this research. Individuals participating in the study as well as future administrators, teachers and students in institutions of higher education may benefit from knowledge gained in the study. For further information about the study, please contact Matthew Hora at hora@wisc.edu, (608-265-0448). If you have any questions regarding your rights as a research participant, please contact the University of Wisconsin–Madison Education Research Institutional Review Board (or IRB) office at 608-262-9710.

I agree to participate in the focus group. □ Yes □ No

I give my permission to have my comments recorded. □ Yes □ No

___________________________________________
Printed Name

___________________________________________
Signature Date
Appendix E

Student Focus Group Protocol for TPDM Study

Introductory statement
Good (morning/afternoon) everyone and thank you very much for coming. We’ve asked you all here as part of a study on student study habits in undergraduate science and engineering courses, and your participation and insights are greatly appreciated. [name tags]

Also, information shared within this focus group should be kept confidential and not be disclosed to others outside of the group. However, confidentiality cannot be maintained within the focus group as other participants will see and hear what you say. Before we start, I have a consent form for each of you to sign, and here is your gift card for participating.

So what we’ll do is first a round of introductions, and then I’ll pose 4 or 5 questions to the group, and then we’ll be done! Some ground rules for this conversation – chime in with your answers or opinions whenever you like, but please don’t interrupt other speakers and please show respect for others’ views and experiences with no disparaging remarks. [brevity – identify yourself]

So the first question:

1. Can you please tell me about your experience in today’s class? What parts of the class did you find helpful, and which parts did you find less helpful?

2. What are your preferences for how faculty teach courses like this? Why?

3. When it comes to learning, where and when do you think this takes place for you?
   a. In the classroom? When you do homework? When you study for exams?

4. When you attend a lecture in this course, what is it exactly about the classroom experience that you hope to take away to help in your learning?
   a. Notes to study at home? A deeper understanding based on the teacher’s explanations or in-class activities?

5. What do you hope to get out of this particular course? To just pass the course as a requirement for your program, to really understand the material, somewhere in between?
   a. Based on these goals, what are your particular strategies for studying?

6. Please imagine for a moment how you typically study (either doing homework or for an exam) for this course – think about the place, the things or people around you, and the materials you have out on the desk or table. [repeat # of hands]
   a. Can you please describe for me, in as much detail as possible, your typical study situation? [probe for location and resources]
   b. Do you draw upon any digital or online resources to help you study? [show of hands – elaboration for people with hands up; if time, elaboration for others]
c. Do you study by yourself or with others? [show of hands]
d. Do you use any social media to study with others? [show of hands – elaboration for people with hands up; if time, elaboration for others]

7. What role, if any, do you think that your past experiences or cultural background has had in influencing your preferences for teaching styles, and how you go about studying?

8. Do you think that there is a problem with undergraduate education in your discipline? Why or why not?
Appendix F

STEM Faculty Motivations to Engage in Teaching Professional Development

Qualitative Phase II Faculty Survey

Welcome!

Faculty Motivation For Teaching Professional Development

Thank you for agreeing to participate in our study concerning faculty work in higher education! Your responses provided on this survey are confidential.

This survey is being conducted at several institutions. Data will be aggregated and we will protect each individual’s identity, including those from underrepresented groups in higher education, by insuring that it is not possible to identify the institution and specific department of any participant.

You are not required to provide your name for this survey. However, you may be willing to serve as a participant for the interview portion of this study. If you chose to do this, you will be instructed to provide your contact information at the end of the survey. Including your name and contact information means that your survey responses are no longer anonymous to the researchers, although they will remain confidential in aggregate reporting.

This survey has received approval from each researcher’s Institutional Review Board. Please read the Research Participant Information and Consent Form. By participating in and completing this survey, you are providing informed consent for your data to be used in this study.

The survey will take approximately 15-20 minutes. You may quit the survey at any time.

If you have questions about the survey, please contact Dr. Stephen Schmid at stephen.schmid@uwc.edu, 608-698-4706, or Dr. Jana Bouwma-Gearhart at jana.bouwma-gearhart@uky.edu, 608-332-6165.
Consent to Participate in a Research Study

CONSENT TO PARTICIPATE IN A RESEARCH STUDY: FACULTY MOTIVATION FOR TEACHING PROFESSIONAL DEVELOPMENT

• RESEARCH PARTICIPANT INFORMATION AND CONSENT FORM •

WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?
You are being invited to take part in a research study about your experience as a faculty member at a major research institution. If you volunteer to take part in this study, you will be one of hundreds doing so at one of three major research universities.

WHO IS DOING THE STUDY?
The persons in charge of this study are Dr. Jana Bouwma-Gearhart, of the University of Kentucky, Department of Curriculum and Instruction, and Dr. Stephen Schmid, of the University of Wisconsin–Rock County.

WHAT IS THE PURPOSE OF THIS STUDY?
The purpose of this study is to query faculty members about their development and training as researchers and teachers. By doing this study, we hope to learn about factors and circumstances that may motivate faculty at research universities to engage in teaching professional development and the effects of their participation. In addition, we hope to provide recommendations to the faculty professional development community with respect to 1) motivating faculty to engage in teaching professional development and 2) creating and implementing teaching professional development to best meet the needs of faculty.

WHAT IS MEANT BY “TEACHING PROFESSIONAL DEVELOPMENT”?
By Teaching Professional Development, we mean: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one’s teaching knowledge or competency.

WHAT WILL YOU BE ASKED TO DO?
You will be surveyed and, possibly, interviewed about your experiences as a faculty member. Specifically, you will respond to questions concerning your preparation as a faculty member and your experience with Teaching Professional Development.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?
Data will be gathered online. You will be asked to log on to a secure survey server two to three times during the course of this study. We anticipate that each survey will take you approximately 15-20 minutes to complete. The total amount of time you will be asked to spend completing surveys for this study is no more than two hours over the next 12 months.

Research participants may elect to participate in follow-up, in-person interviews, although relatively few will actually be selected to participate in interviews. If you are chosen to participate in these interviews, the investigators will come to your home campus for the interviews. If you serve as an interviewee for this study, you will be asked to take part in one to two interviews, at most, over the next 24 months. Each interview will take no more than two hours. The total amount of time you may spend being interviewed for this study is roughly two to four hours over the next 24 months.

ARE THERE REASONS WHY YOU SHOULD NOT TAKE PART IN THIS STUDY?
Besides the small time commitment required to be part of this study, and potential negative effects associated with that, we see no other reasons to not take part in this study.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?
To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.
WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?
There is no guarantee that you will get any benefit from taking part in this study. However, some people experience positive effects when given the chance to reflect on professional and personal experiences. Your willingness to take part may, in the future, help post-secondary institutions to better meet the needs of future and practicing faculty members like yourself.

DO YOU HAVE TO TAKE PART IN THE STUDY?
If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep any benefits and rights you had before volunteering.

IF YOU DON’T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?
If you do not want to be in the study, there are no other choices except not to take part in the study.

WHAT WILL IT COST YOU TO PARTICIPATE?
There are no costs associated with taking part in the study.

WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?
You will not receive any financial rewards for taking part in this study. However, you may experience benefits from reflecting on your experiences as a researcher and teacher.

WHO WILL SEE THE INFORMATION THAT YOU GIVE?
The information you provide for this project will only be seen by the researchers. All data will be reported in aggregate and every attempt to protect your identity in the reporting of the data will be taken.

CAN YOUR TAKING PART IN THE STUDY END EARLY?
If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. You will not be treated differently if you decide to stop taking part in the study. The individuals conducting the study may need to withdraw you from the study. This may occur if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

ARE YOU PARTICIPATING OR CAN YOU PARTICIPATE IN ANOTHER RESEARCH STUDY AT THE SAME TIME AS PARTICIPATING IN THIS ONE?
You may take part in this study if you are currently involved in another research study.

WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?
Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact the principal investigator, Dr. Jana Bouwma-Gearhart at (859) 257-6929. If you have any questions about your rights as a volunteer in this research, contact the staff in the Office of Research Integrity at the University of Kentucky at 859-257-9428 or toll free at 1-866-400-9428.

WHAT IF NEW INFORMATION IS LEARNED DURING THE STUDY THAT MIGHT AFFECT YOUR DECISION TO PARTICIPATE?
If the researchers learn of new information in regards to this study and it might change your willingness to stay in this study, the information will be provided to you. You may be asked to sign a new informed consent form if the information is provided to you after you have joined the study.

WHAT ELSE DO YOU NEED TO KNOW?
We are happy that you are considering participation in this study!
Consent Acceptance

I have read the Research Participant Information on the previous page and I consent to be a research participant in this study.

Yes (Continue the survey)

☐ No (Exit the survey)
Teach

Are you currently teaching or have you taught within the past five (5) years at an institution of higher education?

☐ Yes

☐ No
Demographics

The following questions concern your demographic.

Are you Male or Female?

- [ ] Male
- [ ] Female
- [ ] No Answer

What is your race?

- [ ] American Indian/Alaska Native
- [ ] Asian
- [ ] Black
- [ ] Hispanic, any race
- [ ] Native Hawaiian/Pacific Islander
- [ ] White
- [ ] Multiple Race
- [ ] Other
- [ ] No Answer

How old are you?

Pick one
What is your current title?

- [ ] Lecturer/Instructor
- [ ] Post-doc
  - [ ] Assistant Professor
  - [ ] Associate Professor
  - [ ] Full Professor
  - [ ] Emeritus
  - [ ] Other (please specify)
Demographics
At which institution are you currently employed? (Pick your primary institution if affiliated with more than one.)
*Pick One institution

Is this the only academic institution of higher education at which you have been employed as a faculty member (not including graduate school)?

Yes
No

☐

☐
## Demographics

At what other institution of higher education were you employed prior to your current or most recent appointment (not including graduate school)?


In what capacity were you employed at this prior institution?

- [ ] Lecturer/Instructor
- [ ] Post-doc
- [ ] Assistant Professor
- [ ] Associate Professor
- [ ] Full Professor
- [ ] Emeritus
- [ ] Other (please specify)


Demographics

How many years, cumulatively, have you been at your current institution?

- Less than one year
- 1-3 years
- 4-6 years
- 7-9 years
- More than 10 years

Which of the following terminal degrees do you hold? (Select all that apply.)

- Master's degree
- Ph.D.
- J.D.
- M.D.
- M.B.A.
- Other (please specify)

Are you tenured at your current or most recent higher education institution of employment?

- Yes
- No
Demographics

- Are you on a tenure track?
  - Yes
  - No
Demographics

How long until you achieve tenure?

- One year or less
- Two years
- Three years
- Four years
- Five years
- Six years
- More than six years
Discipline Demographics
In which NSF/CIP discipline does the department that employs you fall? Please make your selection from the appropriate drop down menu.

Agricultural Science

Chemistry

Computer Science

Engineering

Environmental Science

Geosciences

Life/Biological Sciences

Mathematics

Physics/Astronomy

Other (not listed above)
Discipline Demographics

Is the predominant amount of your TEACHING done through the department you selected above?

☐ Yes

☐ No
Discipline Demographics

Since this is not the department in which you do a predominant amount of your teaching, in what department do you predominantly teach?
Is the predominant amount of your RESEARCH done through the department you selected above?

- [ ] Yes
- [ ] No
Since this is not the department in which you do a predominant amount of your research, in what department do you predominantly research?
Graduate Student Demographics

At what institution(s) were you a graduate student?

When did you matriculate with the most advanced degree that you hold with respect to your current position? (Pick an option from the drop-down menu.)
The following series of questions will ask you about your past experiences with teaching and research.
Professional Activities for Past Five Years

For the next two questions, consider your professional activities from the past five years (or less if you are a relatively new academic).

What are the respective percentages of your time to be devoted to the following activities per typical academic year per your CONTRACT? (Please estimate to the best of your ability.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contract Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td></td>
</tr>
</tbody>
</table>

What are the ACTUAL percentages of your time devoted to the following activities per typical academic year? (Please estimate to the best of your ability.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Actual Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td></td>
</tr>
</tbody>
</table>
### Perception as Researcher

This set of questions concerns your and others’ perceptions of you as a RESEARCHER. Please respond to each of the following items in terms of how true it is for you.

<table>
<thead>
<tr>
<th>Item</th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>I was adequately prepared in graduate school to be a researcher.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I learned how to research after graduate school while researching.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have mostly learned to research by reflecting on or studying the</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>processes and skills associated with doing research.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with my research skills.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am a strong researcher when compared to my colleagues. My students</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I know others with whom I can discuss issues and problems regarding</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>my research.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I regularly discuss issues and problems regarding my research with</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Perception as Teacher

This set of questions concerns your and others’ perceptions of you as a TEACHER.

Please respond to each of the following items in terms of how true it is for you.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>I was adequately prepared in graduate school to be a teacher. I learned how to teach after graduate school while teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have mostly learned to teach by reflecting on or studying the processes and skills associated with teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with my current teaching skills.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am a strong teacher when compared to my colleagues. My students see me as an effective teacher.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My colleagues see me as an effective teacher.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My administrators see me as an effective teacher.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I know others with whom I can discuss issues and problems regarding my teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I regularly discuss issues and problems regarding my teaching with others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Perception as Teacher and Researcher

This set of questions concerns your perceptions of yourself as a TEACHER AND RESEARCHER.

Please respond to each of the following items in terms of how true it is for you.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>I consider myself a better researcher than teacher.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I consider myself a better teacher than researcher.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I define myself primarily as a researcher.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I define myself primarily as a teacher.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please respond to each of the following items in terms of how true it is for you with respect to your TEACHING.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel confident in my teaching abilities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am capable of improving my teaching abilities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am able to achieve my teaching goals.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel able to meet the challenge of teaching well.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please respond to each of the following items in terms of how true it is for you with respect to your RESEARCH.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel confident in my research abilities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am capable of improving my research abilities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am able to achieve my research goals.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel able to meet the challenge of researching well.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Intro to TPD

The next set of questions will ask about your past exposure to training as a teacher and your motivations for training to develop your teaching.

For purposes of this survey, TEACHING PROFESSIONAL DEVELOPMENT is defined as: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one's teaching knowledge or competency.
Participation in Teaching Professional Development

Have you ever IN FACT participated in Teaching Professional Development* (either as a graduate student or as a faculty member) at an institution of higher education?

*TEACHING PROFESSIONAL DEVELOPMENT is defined as: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one's teaching knowledge or competency.

☐ Yes

☐ No
Time of TPD Training

At what point have you participated in Teaching Professional Development? (Select all that apply)

☐ As a graduate student
☐ As a faculty member at a higher education institution
☐ Other (please specify)
Reasons for Participating in Teaching Professional Development

The following series of questions relate to your reasons for participating in Teaching Professional Development*.

Different people have different reasons for participating, and we want to know how true each of these reasons is for you.

*TEACHING PROFESSIONAL DEVELOPMENT is defined as: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one's teaching knowledge or competency.

I participate in Teaching Professional Development . . .

<table>
<thead>
<tr>
<th>Reason</th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because I feel like it's a good way to improve my teaching skills.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because others would think badly of me if I didn't.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because learning to teach well is an important part of being a professor.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because I would feel bad about myself if I didn't.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I am likely to follow others’ suggestions regarding my teaching . . .

<table>
<thead>
<tr>
<th>Reason</th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because I would get an award of some kind.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because I believe others’ suggestions will help me teach effectively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because I want others to think that I am a good teacher.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because it's easier to do what I'm told than not.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because it's important to me to do well at teaching.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because I would probably feel guilty if I didn't comply with others’ suggestions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because I recognize that person(s) is more knowledgeable about teaching than I am.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The reason that I will continue to broaden my teaching skills is . . .

<table>
<thead>
<tr>
<th>Reason</th>
<th>Not at all true</th>
<th>Somewhat true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because it's exciting to try new teaching techniques.</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Because I would feel proud if I did continue to improve at teaching.</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Because it's a challenge to improve my teaching.</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Because it's interesting to use my improved skills to better teach my students.</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Frequency of TPD Participation

You answered earlier that you have participated in Teaching Professional Development.

(For the next question, please do not count multiple classes at one training workshop or seminar as more than one opportunity. We are interested in learning the number of distinct Teaching Professional Development opportunities in which you have participated.)

Have you participated in MORE THAN ONE Teaching Professional Development opportunity (where that opportunity was a distinct course or training session separate in time and scope)?

- [ ] Yes
- [ ] No
Number of TPD Engagements

In how many Teaching Professional Development opportunities have you participated?

(Please do not count multiple classes at one training workshop or seminar as more than one opportunity. We are interested in learning the number of distinct Teaching Professional Development opportunities in which you have participated.)

- 2-3
- 4-5
- 6 or more
# Initial Motivations for Teaching Professional Development

Thinking back to the FIRST time you engaged in Teaching Professional Development, what INITIALLY motivated you to pursue this opportunity?

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I wanted to become a better teacher.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I was required to take this type of training as part of my condition for employment.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>I had to improve my teaching skills to address personally recognized deficiencies in my skills.</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>I had to improve my teaching skills to improve my prospects for tenure.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>I felt I could be a more effective teacher than I currently am.</td>
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<td>☐</td>
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<td>I realized my students' performance is related to my teaching effectiveness.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Improving my teaching skills would make me more respected among my colleagues.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Improving my teaching skills would result in better teaching evaluations from my students.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I felt I was less skilled as a teacher than as a researcher and I wanted to equalize my competencies.</td>
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<td>☐</td>
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<tr>
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<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I wanted a raise.</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>I had seen how it improves the teaching of those who have taken it.</td>
<td>☐</td>
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</tr>
<tr>
<td>I wanted to give my students the best educational experience I could offer.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>I thought teaching is an inherently valuable activity.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Statement</td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
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<tr>
<td>• I wanted the respect that comes from being a good teacher.</td>
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<tr>
<td>• I enjoyed teaching.</td>
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<tr>
<td>• I would feel guilty knowing that I could improve my teaching skills but decide not to pursue additional training.</td>
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</tr>
</tbody>
</table>

Is there some other reason(s) not listed?
### Most Recent Motivations for Teaching Professional Development

Now, thinking about your MOST RECENT Teaching Professional Development opportunity(ies), what motivated you to pursue your most recent opportunity(ies)?

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>• I wanted to become a better teacher.</td>
<td></td>
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<tr>
<td>tenure.</td>
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</tr>
<tr>
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<tr>
<td>could offer.</td>
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<tr>
<td>• I thought teaching is an inherently valuable activity.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Reason</td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>I wanted the respect that comes from being a good teacher.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I enjoyed teaching.</td>
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<td>I would feel guilty knowing that I could improve my teaching skills but decide not to pursue additional training.</td>
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<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Is there some other reason(s) not listed?
### Initial and Most Recent Comparison

Thinking about both your INITIAL and MOST RECENT Teaching Professional Development opportunities, state the degree to which you agree with the following questions.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>• My MOST RECENT reasons for pursuing Teaching Professional Development were primarily influenced by my INITIAL encounter with this kind of opportunity.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>• My INITIAL Teaching Professional Development opportunity was a positive experience.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>• I pursued my MOST RECENT Teaching Professional Development opportunity for reasons that were NOT influenced by my INITIAL experience.</td>
<td>○</td>
<td>○</td>
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<td>○</td>
</tr>
<tr>
<td>• My MOST RECENT Teaching Professional Development opportunity was a positive experience.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>• I plan to pursue more Teaching Professional Development opportunities.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Additional Comments

Besides those listed above, are there any other factors that have played a role in your continued interest in pursuing Teaching Professional Development?

☐ No

Yes (please specify)
Intro to TPD Reasons

The next two sets of questions concern your reasons FOR and FOR NOT pursuing Teaching Professional Development. Please answer the questions regardless of your past exposure to Teaching Professional Development.

For purposes of this survey, TEACHING PROFESSIONAL DEVELOPMENT is defined as: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one's teaching knowledge or competency.
Pursuing Teaching Professional Development

This set of questions concerns your reasons FOR pursuing Teaching Professional Development*, even if you have not engaged Teaching Professional Development.

*TEACHING PROFESSIONAL DEVELOPMENT is defined as: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one's teaching knowledge or competency.

In answer to the following statements, state the degree to which you agree with the completion of the following statement:

I HAVE OR WOULD ENGAGE IN TEACHING PROFESSIONAL DEVELOPMENT BECAUSE . . .

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
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<tr>
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<td>Strongly Disagree</td>
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<tr>
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<td>• I want to give my students the best educational experience I can offer.</td>
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<tr>
<td>• I think teaching is an inherently valuable activity.</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>• I feel I am a less effective teacher than my colleagues and I want to remedy this.</td>
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<tr>
<td>• I love teaching and want to improve.</td>
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</tr>
<tr>
<td>• I want the respect that comes from being a good teacher.</td>
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<tr>
<td>• I enjoy teaching.</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Are there any other reasons, other than those listed, you have or would engage in Teaching Professional Development?

- No
- Yes (please specify)
Not Pursuing Teaching Professional Development

This set of questions concerns your reasons FOR NOT pursuing Teaching Professional Development*, even if you have not engaged Teaching Professional Development.

*TEACHING PROFESSIONAL DEVELOPMENT is defined as: Programs and activities (classes, workshops, talking with mentors, etc.) that engage faculty members in reflection or learning about the practice of teaching, with the intent to improve one’s teaching knowledge or competency.
In answer to the following statements, state the degree to which you agree with the following statement:

I HAVE NOT OR WOULD NOT ENGAGE IN TEACHING PROFESSIONAL DEVELOPMENT BECAUSE . . .

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think the training will not help me in my teaching.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>I do not have time.</td>
<td></td>
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<tr>
<td>I never knew it existed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is not offered at all.</td>
<td></td>
<td></td>
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<tr>
<td>It is not offered at a convenient place or time.</td>
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</tr>
<tr>
<td>Development as a teacher is not an activity that my DEPARTMENT supports with respect to tenure prospects.</td>
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<tr>
<td>Development as a teacher is not an activity that my DEPARTMENT supports for merit raise purposes.</td>
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</tr>
<tr>
<td>Development as a teacher is not an activity that my CAMPUS/INSTITUTION supports with respect to tenure prospects.</td>
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<tr>
<td>If I spend too much time or energy developing my teaching skills, then I will be thought a less legitimate researcher.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I spend too much time or energy developing my teaching skills, then I will not have time for my research.</td>
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<tr>
<td>I am first and foremost a researcher and teaching is secondary to my primary objectives.</td>
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<tr>
<td>I am already a good enough teacher without need for improvement.</td>
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<tr>
<td>I do not care how my students view my teaching.</td>
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<tr>
<td>I do not care how my colleagues view my teaching.</td>
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<tr>
<td>Becoming a more effective teacher will not provide me any additional financial benefits.</td>
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<tr>
<td>Becoming a more effective teacher is not important to me.</td>
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</tbody>
</table>

Are there any other reasons, other than those listed, that makes you not willing to engage in Teaching Professional Development?

- [ ] No
- [ ] Yes (please specify)
Exit Invitation

Thank you for taking the time to complete this survey. As part of the broader research project, would you be interested in being involved in personal interviews with this survey's investigators? Doing so would require, at most, two more hours of your time.

Including your name and contact information means that your survey responses are no longer anonymous to the researchers, although they will remain confidential in aggregate reporting.

If you are interested, please type your name and email address in the boxes below so the Investigators may contact you about participating in a personal interview. Including your email address neither obligates you to participate in the future if you change your mind nor does it guarantee you will be asked to participate. Your participation will be kept confidential.

Name

Email

Thank you

Thank you for participating.

If you have any comments about this study, please include them below